Purchasing Performance:

A Public Versus Private Sector

Comparison of Commodity Buying

A Dissertation

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The completion of a dissertation marks one of those rare times in your life in which you can attempt a full accounting of the individual shoulders you have climbed on or boosts you have received from teachers, friends, family, mentors, co-workers, and acquaintances. In another sense you are drawing a thread through the principals that have had a profound influence on your life. This thread forms your evolving web of relationships guiding your life. My web was instrumental in accomplishing and completing my research.

The most important teachers in my life have been my mother and father. It was on my mother's lap that I cultivated an unquenching love of reading. Even after experiencing the rich academic program at Carnegie Mellon, *Are You My Mother* and *The Cat in the Hat* remain my favorite books. Mom, thank you!

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Far and away the biggest support I have received throughout my career has come from Bob Kent. He is also a good friend of Carnegie Mellon. For more than 10 years he was the DoD's program manager for the Software Engineering Institute, directing more than $200 million in research and engineering on the Carnegie Mellon campus. I started working for him as a young lieutenant and I could not have asked for a better boss. More importantly, he paved the way for me to come first to the Software Engineering Institute and later to the Heinz School to study. I learned two valuable lessons from him: 1) the cup is always half full when it comes to people and 2) give people responsibility and then get out of the way. He gave me opportunities as a junior officer that most senior officers only dream of getting, such as demonstrating and briefing one of his successful system developments to the Chief of Staff of the Air Force. He was all about cultivating the Air Force's next generation of system and software development managers. I have been avoiding him for the last year over my embarrassment over not finishing this in a timely fashion. That is about to change.

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My time at the Software Engineering Institute contributed to my success as a graduate student. The organization had a strong influence on my education as a software manager and then later in my

choice of research topics (incentives facing software organizations). I worked with some sharp people and benefited greatly from the wisdom of others: Mark Paulk, Stan Rifkin, Walker Royce, Jim Withey, Mike Konrad, Paul Byrnes, Sally Cunningham, Tom Brandt, Larry Druffel, Linda Levine, Priscilla Fowler, Woody Mead, Jane Siegel, Janice Marchok, Peter Capell, Dave Kitson, Pat Hanavan, Watts Humphrey, and John Foreman. A little known fact is that the SEI runs primarily because of its excellent support staff: Debbie Punjack, Marcia Theoret, Betsy Straitliff, Pat Grimes, and Cathy Cywinski. I received the best support while at the SEI from the library staff: Karola Yourison, Sheila Rosenthal, and Terry Ireland. No library possesses a finer staff.

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1.0 Introduction

Students of defense procurement, as well as the typical citizen who occasionally reads a newspaper or watches the evening news, agree on one thing: the Department of Defense (DoD) is an inept buyer of goods and services. Thompson [1992-93], for example, observes the conventional wisdom as riddled with fraud and abuse, with overcharging, payroll padding, misappropriation of government property, bribery, kickbacks, and conflicts of interest commonplace occurrences. The media and to a much lesser extent the academic literature have provided many examples fostering these beliefs: $436 hammers [Comeau, 1984], jet engines purchased by the DoD without warranty at a price 20 percent higher than the same commercial sector engines under warranty [Rich and Janos, 1994], several cases of bribery and payoffs within the senior DoD civilian staff and major defense contractors during the Reagan-Bush era [Pasztor, 1995], $7,000 video tape recorders [Gansler, 1978], $7,600 coffee pots, $916 plastic stool leg cap, $318 plastic toilet pans, and $9,600 allen wrenches [Comeau, 1984]. So prevalent are these views that the DoD Inspector General, Eleanor Hill, the individual primarily responsible for eliminating waste in the military, said she would eliminate the buying of $436 hammers during her August 28, 1995 swearing-in ceremony, more than ten years after the hammer purchase made newspaper headlines across the country. Although these examples relate to defense procurement, Downs and Larkey [1986] showed more generally that people believe the U.S. government is inefficient, ineffective, wasteful, venal, and its employees are overpaid and underworked.

As a result of these common and long-held beliefs, the DoD's acquisition process has been the subject of an interminable string of evaluations, panels, commissions, and study groups for more than thirty years. Historically, reviews of government practices focused on three themes: saving money, increasing efficiency, and downsizing the federal bureaucracy [Moe, 1994]. More specifically to defense, the recommendations have repeatedly centered on exploiting commercial products and services, deregulating defense acquisition by emphasizing outcomes over procedural controls, and emphasizing efficiency of the DoD's internal processes over accountability to congress and the multiple layers of auditors [Thompson, 1992-93; Thompson and Jones, 1994; and Mayer and

Khademian, 1995]. The prevailing view today is that the DoD, because it buys and performs many of the same goods and services, respectively, is little different from the commercial sector; therefore, it should enthusiastically embrace commercial habits [Gore, 1993; Thompson and Jones, 1994; Prager, 1994; Moe, 1994; and Mayer and Khademian, 1995].

The belief that the DoD is an inept or corrupt buyer rests on a fragile bed of anecdotal evidence. There is an absence of systematic research in this arena. It is unclear whether the aforementioned anecdotes are the rule, exceptions, or extenuating circumstances exist to explain the differences in price paid for goods by the defense and commercial buying sectors. Typically, the literature has employed anecdotes focusing only on differences in price, ignoring purchase volumes, representativeness of an item, comparability, contextual information surrounding the item or purchase, and allegedly costly DoD oversight and procurement practices; e.g., the cost of auditors, program management personnel, and inspector generals.

No systematic studies have been performed in this domain comparing the buying performance between the defense and commercial sectors using a large sample of purchases of identical commodities. This is symptomatic of the more general problem of a lack of scholarly research in the defense policy sector, including defense acquisition [Walt, 1991; and Mayer and Khademian, 1995]. The problems with the defense procurement literature can be likened to the more general problem of understanding organizations as identified by March and Simon [1958] forty years ago: "The literature contains many assertions, but little evidence to determine--by the usual scientific standards of public testability and reproducibility--whether these assertions really hold up in the world of fact."

This dissertation tests the validity of the public's beliefs about the DoD by examining the efficiency of defense purchasing relative to the commercial sector. This research compares the purchases of identical commodities drawn from three sectors: electrical, engine, and software. The samples of purchases consist of more than 831,000 items purchased as part of 693 actual contracts or delivery orders. The main questions are: 1) What are the differences in buying performance between the commercial and DoD sectors, 2) What causes the differences, and 3) Is there systematic

evidence to support the public's beliefs? The comparisons consider the price of a good, purchase quantity, relevant contextual information, and the DoD's direct buying costs. The findings are at variance with the conventional wisdom and much of the prior research. These findings, which are based on samples of purchases of identical commodities vastly larger than any sample in the literature, include the following evidence: 1) the DoD significantly outperforms the average commercial sector organization purchasing commodities in each of the sectors examined in this study and 2) that superior DoD buying performance holds even after considering DoD oversight costs.

The findings embodied in this research require careful interpretation. Supporters of the DoD procurement system should *not* extrapolate these findings into the assumption that the DoD is an effective buyer in every market. Detractors of the DoD procurement establishment should *not* discount these findings by clinging to their basic principle that the public sector is inherently and always inefficient. Both parties, however, should demand that the DoD put in place a measurement program exploiting the same or similar measures used in this research. The DoD's product center and depot commanders should report to their commanders and congress how effectively they are spending the taxpayer's money relative to the commercial sector. The centerpiece of this measurement program should be the collection and analysis of systematic evidence of DoD purchasing. Systematic evidence rather than anecdotes or some senior leader's doctrinal opinions must drive the crafting and implementation of public policy improvements.

1.1 Importance of this Research

This is an important time to understand the relative efficiency of defense procurement and how it might be reformed since: (1) funding for defense procurement is enormous but declining; (2) past research has severe limitations; (3) reforms such as privatization, outsourcing, and reductions in DoD oversight may be predicated on a flawed understanding of when defense procurement is efficient; and (4) the DoD is required to continuously monitor (measure outcomes) and improve the efficiency of its operations.

Considering the vast sums expended on defense procurement every year, it is important that public policy researchers understand how well the DoD is purchasing relative to the commercial sector before crafting and implementing reforms. The government procures in excess of $200 billion in systems and material every year. The Defense Department (DoD) spends in excess of $100 billion a year (see Figure 1). Thompson and Jones [1994] have observed that the DoD buys more merchandise than all of the public sector of the United States put together, $123 billion worth of goods and services in 1992 from 30,000 suppliers.

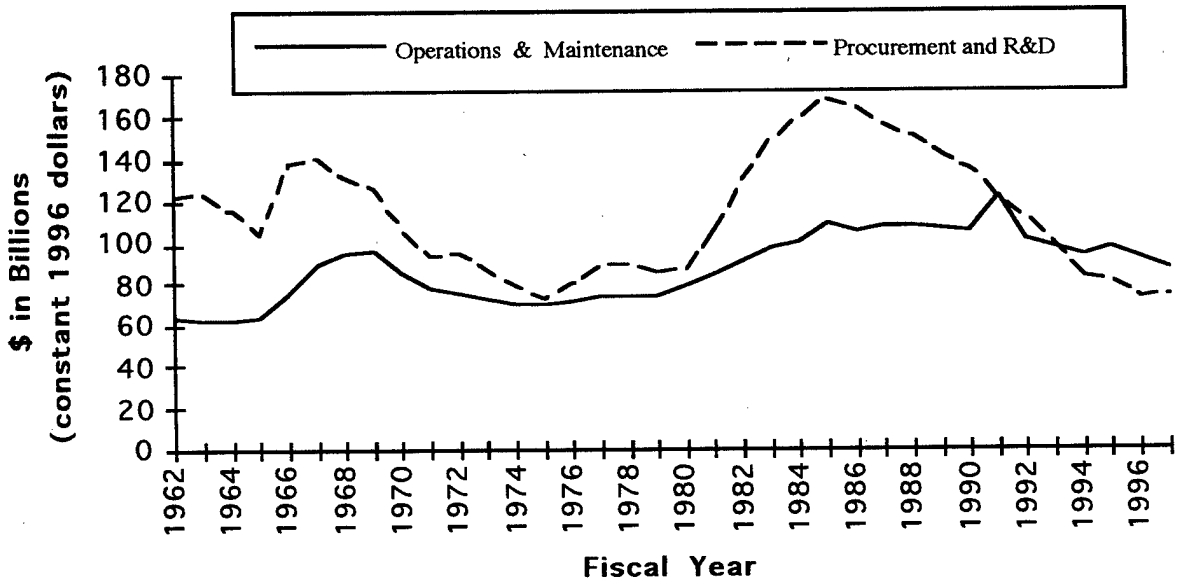

Figure 1: DoD Funding for Research, Development, and Procurement; and Operations and Maintenance for 1962-1997 in Constant FY96 Dollars.

Although the DoD procures enormous amounts of material, its current procurement situation is critical because its purchasing power in real terms, as shown in Figure 2, is receding. Contrary to former DoD Secretary Frank Carlucci's plan for "doing more with less," the DoD's present position is one of "doing less with less" as the defense budget in real terms declines. The funding available for procurement has declined over 70 percent since 1985, when it comprised 31 percent of the DoD budget, but is now only 17 percent [Gansler and England, 1996]. The Cold War is no longer a driving force for increased defense spending or sustaining the Eighties-era defense budgets.

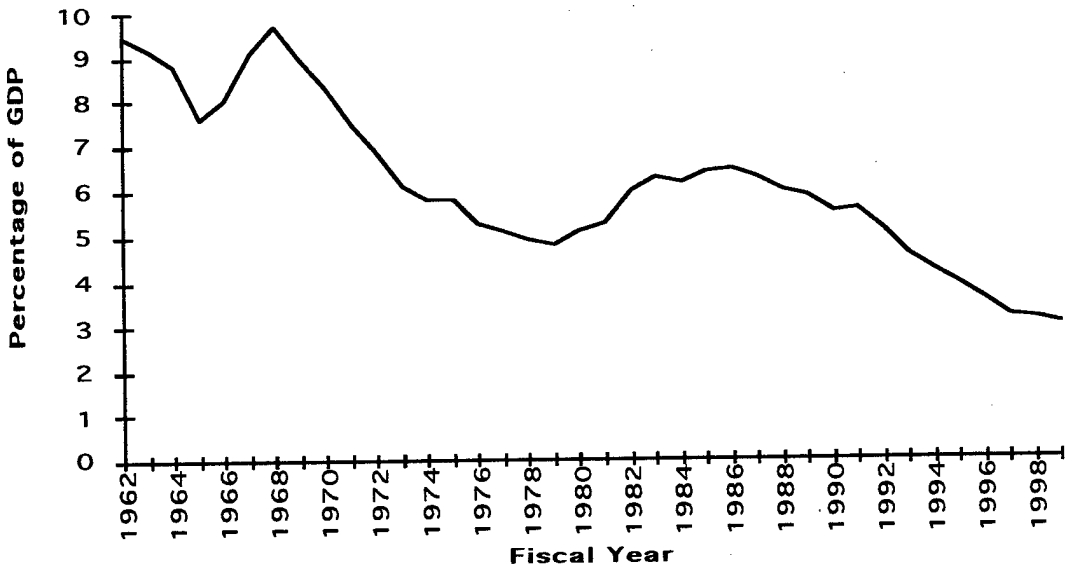

Figure 2: Defense Spending as a Percentage of GDP for 1962-1999.

As the budget falls, so does the size of the military forces as well as the number of civilians that support the military in critical positions, particularly in the acquisition or purchasing arena. Realistic reductions in personnel must carry with them process changes to enable the military to function effectively with fewer people. For example, the Air Force announced a number of acquisition reform initiatives on June 1, 1995, including an effort to trim procurement personnel by at least 50 percent. The other military services and agencies of government will surely follow. The Congress and the President have been no less ambitious in their efforts to reform the DoD's buying practices [Gore, 1993]. Together, the legislative and executive branches of government have numerous process action teams trying to "reinvent" government procurement. The Clinton Administration has already made it somewhat easier to buy commercial items through the passage of the Federal Acquisition Streamlining Act of 1994 [Heberling and Houpt, 1995] and still easier with the passage of the Federal Acquisition Reform Act of 1996 (FARA). The enormous sums of money coupled with the declining budget highlight the importance of understanding the effectiveness of defense procurement practices before offering reforms.

Another way to view the enormity of defense procurement is by the number of contracts awarded to private corporations each year. Gansler [1989] observed that the overwhelming majority of contract actions involve standard or commercial-type items, but the overwhelming share of the defense dollars go for a few major weapons systems. In fiscal years 1995 and 1996, the DoD awarded 10.6 and 8.7 million contracts worth more than $131 and $132 billion, respectively [DoD, 1997]. In fiscal year 1996, as shown in Figure 3, of the 8.7 million contracts, 8.3 million were for goods and services contracts, primarily standard items, worth less than $25,000. When totaled, the 8.3 million contracts amount to $12.4 billion. Approximately 275 thousand of the 8.7 million contracts in fiscal year 1996 were each worth more than $25,000 for a total procurement value of $109 billion. The remaining contracts were interagency purchases to cover Foreign Military Sales. With this high volume of buying, even if the DoD could achieve six sigma quality,[1] the holy grail of manufacturing quality, the DoD would still face approximately five to eight procurement disasters per year.[2]

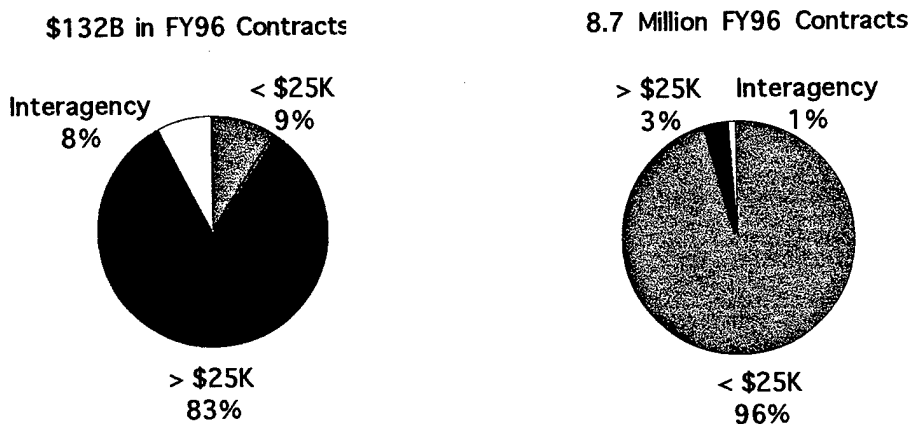

Figure 3: Delineation of Standard Items (<$25,000) and System Procurements (>$25,000) Contracts in Fiscal Year 1996.

Rational procurement reform must be grounded in rigorous knowledge of what the DoD pays relative to the commercial sector for equivalent goods. Not only is this important from a public

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[1]Six sigma quality implies that your product is of such high quality that your defect rate can be measured using a single digit per one million items manufactured.

[2]Smith [1988] captures this perspective in a conversation from the mid-1980's between Secretary of Defense Casper Weinberger and Undersecretary for Research and Engineering Richard DeLauer, with Mr. DeLauer speaking: "Christ, we have sixteen million procurement actions a year. If you're better than Ivory Snow, ninety-nine and one half percent pure, that's still one half percent of mistakes. Christ, that's eight thousand a year!"

policy perspective, but this level of insight would enable the DoD's purchasing organizations to measure and then continuously improve their operations. Closer examination of the aforementioned purchasing anecdotes reveals that some never occurred, circumstances surrounding others were distorted, some were discovered by the DoD's system of oversight but not always resolved in the best interests of the taxpayer, and others were just poor buying on the part of the DoD. For example, $9,600 allen wrenches were never purchased by the DoD, rather the part appeared on an unnegotiated contractor price list [Air Force Logistics Command, 1986]. Nevertheless, most past research supports the general trend of the anecdotes: the DoD pays a premium when buying goods.

Unfortunately, past research on defense purchasing has severe limitations. The most compelling weakness facing this genre of research is that there has not been any type of systematic analysis of DoD purchasing. Much of what can be described as scholarly research does little more than use selected anecdotes as foils to foster some public policy change. These studies rely on small, unrepresentative samples to argue superiority of commercial sector behavior [Mandel, 1977; Michelli, 1977; Stimson and Barnett, 1980; Gansler, 1982; Comeau, 1984; Stewart, 1986; Senate Report 101-62, 1989; CSIS, 1991; Coopers & Lybrand/TASC, 1994; and Thompson and Jones, 1994]. The small samples are further limited by relying on price comparisons that ignore purchase volume [Mandel, 1977; Michelli, 1977; Stimson and Barnett, 1980; Gansler, 1982; Comeau, 1984; Stewart, 1986; Senate Report 101-62, 1989; CSIS, 1991]. Some analyses were skewed by examining only those cases where commercial sector buying was better than the defense sector or by examining only DoD costs of regulation while ignoring the benefits [Angier, White, and Horowitz, 1979; Comeau, 1984; and Coopers & Lybrand/TASC, 1994]. Another common feature of past research is the lack of contextual information that could explain a price discrepancy, such as comparing goods that were not really identical or never purchased [Mandel, 1977; Michelli, 1977; Gansler, 1982; Comeau, 1984; Rich and Janos, 1994; and Coopers & Lybrand/TASC, 1994]. A particularly egregious example of this practice can be found in the alleged overspecification of fruitcake, a product the DoD used to purchase using an 18-page specification [Gansler, 1989]. Though the story was a favorite of the media and procurement literature, the part of the story that

was often not mentioned is that the DoD processes, though questionable on the surface, yielded a good fruitcake at roughly half the commercial market cost [Gansler, 1989; Dunnigan and Nofi, 1991; and Thompson and Jones, 1994].

Generalizing as to whether the DoD pays more than the commercial sector for an equivalent good is not a trivial task. The DoD is not a monolithic organization with one procurement style purchasing one type of good with a singular cost structure. Gansler [1989] observes defense purchasing to be extremely decentralized, with thousands of purchasing offices scattered all over the world under local supervision. What precisely comprises the cost of an item purchased by the DoD varies by the item. The goods purchased by the DoD range from simple commodities, such as hammers, bolts, or transistors, to highly complex unprecedented systems, such as the Air Force's newest fighter, the F-22. Figure 4 graphically represents the span of goods the DoD procures.

To ensure that identical goods are being compared, this dissertation focuses on commodities. As more complex DoD goods are examined, it becomes increasingly more difficult to find identical commercial counterparts. For example, no commercial counterpart exists for the Air Force's F-22 fighter or B-2 bomber. Surely, however, there are commodities purchased for or in support of those aircraft that are sold in the commercial marketplace.

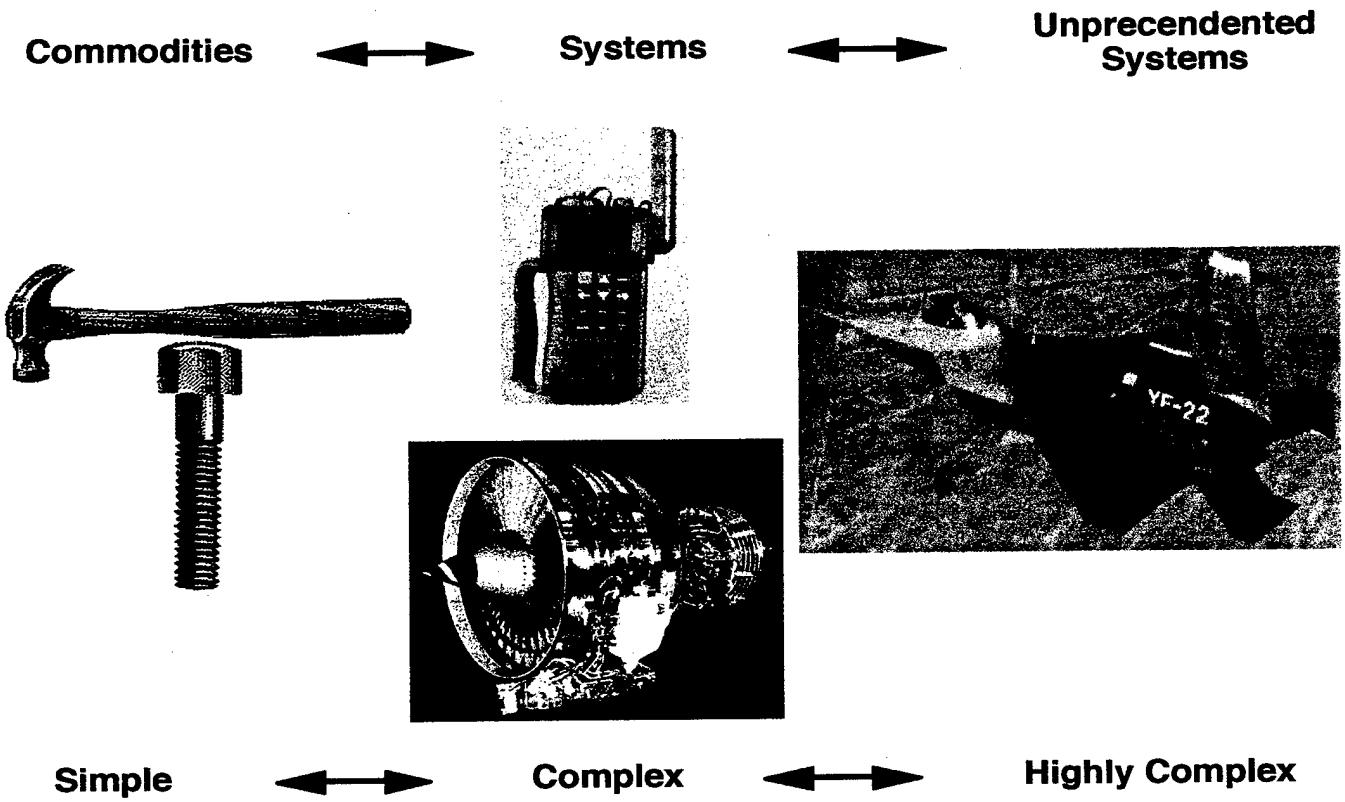

Figure 4: Span of Goods Purchased by the DoD.

Commodities or commercial items purchased by the DoD may be found wholly or as part of contracts that exceed the $25,000 threshold used in the past to label standard or commercial purchases. Systems and subsystems of unprecedented systems within the DoD contain some and, in many cases, all commercial items. One cannot assume the 8.3 million DoD contracts under $25,000 in 1996 represents the population of commercial purchases. For example, the C-17 cargo aircraft is certainly an unprecedented system given its robust performance requirements; however, it is flying with purely commercial engines. The F-22 fighter aircraft identified in Figure 4 will, for example, use a purely commercial supply and maintenance system. Similarly, the "Systems" identified in Figure 4 are purely commercial items, but both were purchased using contracts that significantly exceeded $25,000. The top "System" in Figure 4 is the GPS receiver purchased by the Army and the bottom "System" is the CFM-56 jet engine purchased by the Air Force. Both are purchased at or below commercial prices. Conversely, many of the purchases under $25,000 are surely for small,

uneconomic lot sizes of DoD-unique components for which no commercial counterparts exist. Figure 5 highlights the overlap of DoD and commercial items comprising the population of purchases by the DoD. This overlap, as well as the varying procurement rules when buying systems versus commodities, highlights the difficulty finding identical items for comparison as well as offering consistent, meaningful reforms.

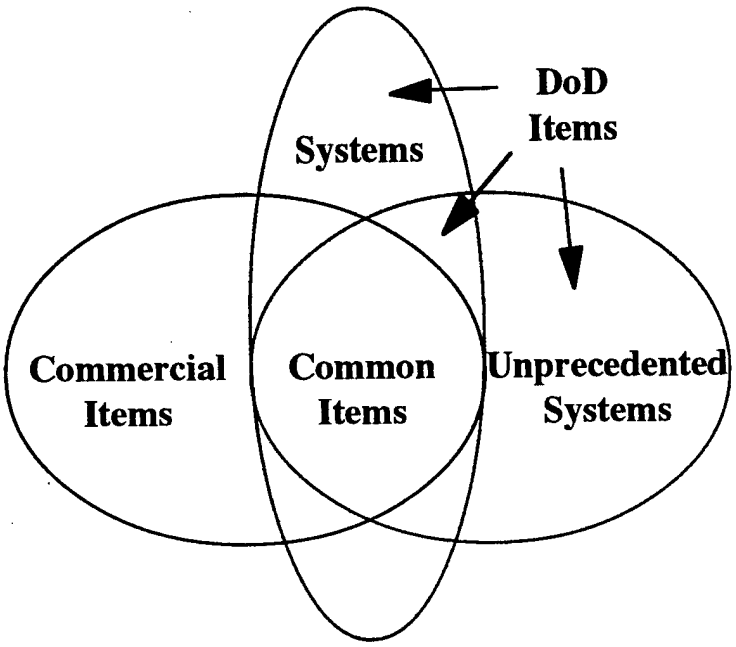

Figure 5: Composition of Goods Purchased by the DoD.

It is not easy to gather a large sample of *actual, identical* commodity purchases, gain government or commercial sector cooperation, and determine a fair basis of comparison. First, government buying personnel have myriad abstruse rules and procedures they must follow to purchase many items. In the past, for example, an aircraft carrier commander in port and requiring lumber had to follow special congressionally-enacted buying procedures rather than purchase from the local lumberyard. Second, video tape recorders for a military jet aircraft, as an example, are not the same as those any consumer could purchase at their local department store. Third, media exploitation of past anecdotes of alleged incompetent government buying has created an atmosphere

of fear that translates into a general unwillingness to take part in this genre of research.[3] Fourth, some commercial entities are reluctant because of possible proprietary value in the data embodying their sales behavior.

In addition to the large commodity sample, a small collection of case studies is developed to explore the labor costs associated with the DoD's purchase of the commodities comprising the samples from different industry sectors. The price the DoD pays for an item is not the only cost the taxpayer must sustain. The DoD must also sustain the buying processes and organization conducting the purchases. The case studies will consider these costs in evaluating the relative efficiency of the DoD's purchases compared to the commercial sector.

1.2 Contributions

This research presents strong evidence that there are some areas of buying in which the DoD outperforms the average commercial firm. This dissertation paves new ground by gathering several large samples of identical commodity buys from different sectors. Whether the sector is electronic, engine, or software commodities, the DoD outperforms the average commercial sector firm buying at wholesale prices.

This research presents a new method for comparing the prices paid by the DoD and commercial sector buyers: "*weighted price difference analysis.*" In the past, mere price comparisons was the method used by researchers and the media. One never had any conception of whether a showcased part or commodity purchase was representative of DoD buying or an outlier. The weighted price difference methodology weights each purchase price by the proportion of expenditures in the entire sample accounted for by this purchase. This has the effect of making high dollar value purchases of greater importance in the analysis. Interestingly, this dissertation

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[3] During the collection of one of the samples and over several nights subsequent to this author's visit to that buying activity, the respective contracting officer had many sleepless nights because of fear over the findings. Though the team felt they were doing a great job (and had the evidence to prove it), they seem to have fallen under the spell of the media and harping from congress and executive branch leaders that the government's buying is generally inefficient and, by inference, the buyers incompetent. So great is this fear that this buyer's management attempted to stop the collection of that sample. This also happened to a lesser extent at another government buying activity. Also, one engine manufacturer refused to take part in this study.

uncovered many egregious purchases by the DoD, but in nearly every case they were for low dollar value items purchased in small quantities. However, once those low dollar value purchases were weighted, their importance in the overall analysis waned. As the quantity size and purchase price increase, the relative efficiency of the DoD's purchases also increased.

Summary Findings: This research shows that once the weighted price differences between the commercial wholesale and DoD sectors were analyzed, the DoD's buying was shown to be 5.9, 47.4, and 34.2 percent more effective within the electronic, engine, and software commodity sectors, respectively. A t-test revealed that each mean was statistically different from zero ($p < .001$). The electronic, engine, and software commodity samples were comprised of 329, 132, and 232 purchases or delivery orders in various quantities, respectively. The largest sample presently found in the literature consists of 40 purchases in varying quantities and only considered the cheaper commercial items in its analysis [Angier, White, and Horowitz, 1979]. This dissertation employs a sample more than 15 times larger.

The total dollar values of the electronic, engine, and software samples using the DoD's actual unit prices are $2.7, $60.9, and $36.3 million, respectively. Even at the macro-level of the sample, this dissertation shows that as the average dollar value of an electronic, engine, or software purchase increased, so did the DoD's relative buying efficiency. Engine buying significantly outperformed software buying and software buying significantly outperformed electronic buying.

Aggregate analysis of the DoD's purchasing performance was no different. Overall, weighted price difference analysis reveals the DoD outperformed the average commercial sector organization using commercial wholesale prices by 41.5 percent. If those same price differences were not weighted, an analysis would reveal the DoD paid 20.7 percent more than the average commercial sector organization. Collectively, the DoD paid $99.9 million for the more than 831,000 items comprising these samples. Using commercial wholesale prices, the average commercial sector firm would have paid $188.7 million for the very same commodities.

A Proposition on DoD Buying: Using an analogy of the typical American consumer, a proposition on DoD buying is introduced: as the total dollar value of a purchase increases, so does the DoD's attention and effort for getting a fair price. If the typical consumer needs only a loaf of bread or gallon of milk, they will more often than not purchase one at the nearest convenience store (7-11) even though they will get a better price at a grocery store; however, if the typical consumer has a long list of items to buy or it is their weekly shopping run, they will undoubtedly go to their local grocery store or discount warehouse for its better prices. On high cost purchases such as automobiles, houses, and appliances, the typical consumer is more likely to thoroughly research sources and comparative shop. The DoD buyer is no different in allocating attention and effort in purchasing.

A simple illustration of the DoD's buying behavior is presented as one of two consumers in Table 1. The first consumer, like the DoD buyer, expends little effort buying cheap items, but as the total purchase value for an item or group of items increases, she allocates greater attention and effort. The second consumer shops where he feels he will get the best price, but he allocates the same amount of effort regardless of the purchase value. Three items are purchased in this example: two grocery items and an automobile. Consumer one purchases the two grocery items at the most convenient location, a 7-11 on her way home from work. Consumer two, however, goes out of his way to shop at his favorite grocery store offering the best prices. For the automobile, consumer one shops multiple dealers and essentially auctions the purchase to the lowest bidder. Consumer two goes to the dealer next to his favorite grocery store and pays sticker price for the automobile. In the aggregate, consumer two pays less in terms of average price difference (40.9 percent lower), but in the actual expenditure of dollars, consumer one is the more effective buyer by nearly $4,500. The DoD buyer behaves in nearly the same fashion as consumer one.

Table 1: Hypothetical Buying of Two Consumers.

	Consumers		
Items	One	Two	Price Difference
Milk	$3.39	$2.11	-0.607
Bread	$1.79	$0.99	-0.808
Mercury Villager	$19,500	$24,000	0.188
Total / Average	$19,505.18	$24,003.10	-0.409

Accounting For DoD's Other Costs to Buy: Another area where this dissertation paved new ground was in factoring the DoD's oversight costs into the total cost equation in order to more accurately evaluate the DoD's relative efficiency. Two case studies from the engine and software commodity sectors considered all DoD purchasing costs and assumed the commercial sector's equivalent costs were zero. Despite this handicap, the DoD outperformed the average commercial sector firm buying at commercial wholesale prices. For example, the DoD paid $59.3 million for 71 engine part contracts while accruing an estimated $8.3 million in labor costs. The total cost to the DoD is $67.6 million. However, if the manufacturer's *best* commercial customer purchased those same parts and purchased them while accruing no labor costs, they would have paid $123 million. The DoD's processes and workforce outperform the *best* commercial sector organization under these circumstances.

The findings are similar for the software sample. The DoD paid $36.4 million for the purchases comprising the sample and incurred an estimated $3.9 million in labor costs to research and purchase the software commodities. However, the average commercial sector firm receiving wholesale prices would have spent $60.5 million for the very same software products. The cost of those same products using commercial list prices would have been $88.4 million. Even when the DoD's costs to buy are considered and a handicapping assumption is made that the associated commercial purchasing costs are zero, the DoD outperforms the average commercial sector organization buying software commodities at wholesale prices.

Why Does the DoD Perform So Well Relative to the Commercial Sector?: There are a variety of reasons explaining the DoD's superior performance relative to the average commercial sector firm. First, the DoD possesses a piece of legislation that is suppose to ensure they pay no more for an item than any other commercial sector firm buying under similar circumstances, although this statute is rarely enforced. Second, for large dollar value purchases, most DoD buyers appear to study their suppliers, aggregate their buys, watch for sales, and negotiate aggressively with suppliers. In the software sector, studying suppliers and waiting for sales, or "specials" as they are called, provided deep savings and indicated that the deepest discounts were often offered by a commercial supplier at the close of a financial reporting period. Aggregating buys is one method the DoD uses to exploit its buying power. However, the data collection, analysis, and forecasting necessary to systematically aggregate purchases is not a standard practice across all DoD product lines. The engine and software sectors perform some level analysis and forecasting within some product lines; however, not all engines receive such attention. Forecasting is especially important if the DoD expects to derive the benefits of "just in time" delivery and aggregating buys to get the greatest quantity-based price breaks. With effective forecasting, the DoD can then enter into long-term contracts with a supplier to provide incremental quantities on a monthly basis over several years. This provides a win-win situation for the DoD and supplier. The DoD is able to glean the benefits of a high quantity buy while accruing savings from reduced inventory. The supplier is able to more effectively plan its production and minimize its inventory of raw materials. This is, however, an area ripe for process improvement by the DoD.

Third, the DoD has the option of collecting cost and pricing data on purchases for which no real commercial market exists, if the purchase is over $500,000, or to support a sole source (competition is not used even though alternative suppliers may exist) purchase of some kind. Collecting cost and pricing data is another example of the DoD exercising its buying power. Cost and pricing data provides visibility into a manufacturer's production costs. It costs the DoD money in terms of buying personnel and on-site labor to collect cost and pricing data. Suppliers also do not like the DoD collecting this information because it cuts into their profits. The engine sector case

studies present evidence that there are circumstances where DoD buying and on-site plant personnel add value and help to contain the DoD's costs through the use of cost and pricing data.

The push towards commercialization of buying within the DoD has been going on for nearly 20 years, with the Coopers & Lybrand/TASC study and the acquisition reform movement helping to accelerate that push within the current administration. Ironically, the acquisition reform movement succeeded in making it more difficult for the DoD to collect cost and pricing data with The Federal Acquisition Reform Act (FARA) of 1996. The irony lies in the DoD leadership's perception of what is and what will continue to be a *commercial practice*: collecting cost and pricing data [Vander Schaaf Testimony, 1995]. Large firms that possess buying power in a market have collected cost and pricing data long before the DoD ever entertained the idea and will continue to do so long into the future. Perrow [1970] has shown that large organizations that possess power over subordinate suppliers regularly audit their records, citing the Ford Motor Company as one specific example. Pfeffer [1978] reinforces this observation of powerful commercial organizations that derive greater profitability from asymmetrical exchanges with suppliers, using General Motors as one example of a firm that gains visibility into its supplier's operations and uses that knowledge to control the price at which it buys. This research's case studies provide evidence that cost and pricing data enhances the DoD's buying position in high dollar value procurements, even when the costs of collecting that data are considered.

Fourth, the DoD will seek secondary sources of supply when they own a set of engineering drawings or when items are available from more than one manufacturer. This has the effect of driving competition into the purchasing process of parts that are generally not sold in the commercial marketplace. Lastly, for items that are bought and sold in large volumes in the commercial sector and are found on a commercial price list, the DoD will often negotiate price breaks off of the commercial list price. The parts for the second commercial engine in the engine sector sample were bought in this manner.

Other ancillary factors to consider but were outside the scope of this dissertation to investigate in any depth involves the personnel comprising the buying units, their motivations,

training, and organizational learning. The DoD's buying units are led predominantly by uniformed officers that are vastly underpaid and over-educated in comparison to their counterparts in industry. The Air Force takes it a step further by placing uniformed officers in key positions throughout the entire procurement process. It is generally believed the officer corps possesses a higher than average sense of duty and dedication to the mission. This esprit de corps can readily be seen on any Saturday or Sunday with the hundreds of cars parked in the Pentagon parking lot or in the parking lots of hundreds of other work locations across the DoD. The DoD's acquisition personnel, though not perfect, must take part in an extensive training and certification program, regardless if one is a low-level buyer or a senior program manager. Because of this training program and the vastness of the DoD's purchasing enterprise, extensive organizational learning occurred over the years, revealing incremental improvements in the DoD's processes. Although the parts scandals of the Eighties provided a wealth of anecdotes, the DoD made extensive changes to improve its buying performance.

Is There Support For These Findings in the Organization Theory Literature?: Once the reasons for the DoD's superior buying performance are distilled, it is clear the organizational framework first presented by Simon [1947] and then March and Simon [1958] offers one interpretation of the DoD's performance. In terms of purchasing, the DoD has several goals it tries to meet across its contracts. For example, undoubtedly the DoD wants a good price that pays a fair profit to its suppliers, but other goals such as support to small businesses and minority-owed firms also enter into the decision process. In order to meet these sometimes conflicting goals, the DoD has searched over time and arrived at a set of procedures or heuristics used to ensure all goals are *satisficed.* To support small businesses, offices were established within each of the DoD's buying organizations for an individual to represent small business interests. Similarly, certain types of contracts for certain services are "set aside" for minority-owned firms. In regards to buying specifically commodities, the use of cost and pricing data, aggregating buys to leverage market

power, or studying one's suppliers are all forms of March and Simon's [1958] use of standard operating procedures or heuristics to effectively accomplish tasks in the workplace.

Cyert and March's [1963] negotiated environment is found within many of the buys comprising the Engine One sub-sample. The DoD and supplier engaged in extensive coordination to better manage interdependence by negotiating long term contracts for high quantity purchases with incremental deliveries that meet the DoD's anticipated utilization. The interdependence exists because these parts were technically sophisticated and of high value to the DoD. Their sophistication diminished the likelihood the DoD would seek an alternative supplier. The supplier needs this business from the DoD and the DoD needs a reliable or the primary supplier. Adaptation or organizational learning can be seen in the software sector buyer's practice of aggregating buys and then waiting until the end of a supplier's financial quarter to execute the buy. The buyers have learned that certain software suppliers will lower prices substantially to increase revenue at the close of a financial reporting period.

Simon's mechanisms of organizational influence can readily be seen in how the DoD organizes and operates its buying organizations [1947]. Work is subdivided among buyers, contracting officers, item managers, engineering support staff, and on-site auditors and technical support. Standard operating procedures are in place for deciding when to seek cost and pricing data, although judgment is part of that process, and for deciding when a purchase is automatic or requires human intervention. The DoD has a system of authority and influence in place, with most notably the practice of having only contracting officers rather than program or item managers awarding contracts. Similarly, only certain contracting officers are allowed to award contracts above certain dollar thresholds. A system of training is in place to cultivate increasing levels of expertise and experience. For example, contracting officers typically start out as buyers, progress to contracting officer for a certain dollar threshold, and then progress to a higher dollar threshold after additional training, experience, and success in passing an oral and written examination.

Overall, the DoD has a set of practices one would expect of an effective organization.

Generalizability of These Findings: The relevance of the samples comprising this research, drawn from the vastly larger body of DoD purchases, requires discussion. One cannot generalize these findings into the vastly more expensive and different world of large system acquisition. However, once a large system has reached its maintenance phase, these findings may be extrapolated to the replenishment of spare parts that are wholly commercial. Those items are purchased using essentially the same processes. For example, the engine parts comprising this research's engine sample are commercial items used within much larger DoD weapon systems, systems that were at one time large system acquisitions.

These findings may be generalized to the larger body of commercial purchases by the DoD, regardless of the purchase threshold. There is no reason other DoD buying organizations are not enjoying the same efficiencies when following the same purchasing rules and regulations. First, the Air Force, for example, has eliminated local purchasing rules and consolidated nearly all of its buying under a singular command. The Air Force is seeking consistency in the execution of buying decisions across the service. Second, more than 90 percent of the purchases within a year are for items under $25,000 that are predominantly standard or commercial items. That constitutes more than two-thirds of this dissertation's sample. Third, 195 purchases comprising this dissertation's sample are from the greater than $25,000 category of purchases, where the vast majority of the DoD's procurement dollars are expended. The purchases comprising this research are representative of commercial items bought within the two broad categories of DoD purchases.

One should not generalize these findings into the arena of DoD-unique parts. Even though the buying processes are essentially the same, commercial alternatives ripe for comparison typically do not exist. However, an interesting anecdotal finding emerged from the engine sample that provides some insight into the efficiency of the DoD's buying performance for DoD- unique items. Some of the commercial engine parts are duplicates of parts found in a militarized engine for which the Air Force possesses cost and pricing data. Those parts are bought at a much deeper discount than the purely commercial parts. This indicates that the DoD is enjoying greater efficiency when buying DoD-unique parts. On the other hand, dissimilar or DoD-unique items are typically

purchased in much smaller, inefficient lot sizes and often require extraordinary engineering effort as well as management oversight. These factors significantly affect the cost of an item. So, one should not extrapolate the findings in this dissertation to the entire population of DoD purchases.

Concluding Remarks: This research's findings sharply contrast with conventional wisdom and the themes permeating much of the literature on defense procurement. This should cause the DoD's policy initiators and facilitators to more carefully consider how they intend to make the DoD a more efficient buying organization. The DoD's leadership needs to more realistically evaluate its push towards "one size shoe fits all" public policy decisions as it tries to commercialize its operation to a greater degree. This research suggests that buying commercial items off commercial price lists will cost the taxpayer *more* money. Uniformly eliminating in-plant oversight personnel that collect cost and pricing data will adversely affect the DoD's purchasing power. Cost and pricing data is a valuable commercial sector tool the DoD buyer should exploit under the appropriate circumstances. The DoD must continue to examine where it has market buying power and then exercise that market power to get the fairest price for the taxpayer. Exploiting market power is a long held behavior for saving money in not only the DoD but also in the commercial sector [Thompson and Jones, 1994]. Certainly within the engine and software commodity sectors the DoD carries important buying power ripe for exploitation.

The analyses embodying this research reveal important measures of efficiency the DoD should but does not consistently measure across its buying organizations. Multiple pieces of legislation over almost forty years have called for government, including the DoD, to measure and improve its operations. The DoD should exploit weighted price difference analysis by collecting samples of its purchases annually at each of its buying activities and compare performance to the average commercial sector organization. At only one site visited as part of this research, the Air Force's software buying activity, was any form of measurement occurring. If the DoD is truly to improve the efficiency of its processes, it needs to perform analyses that reveal how well it is doing today. These analyses need to consider all costs and benefits that can be feasibly gathered. Real

cost/benefit analyses will help the DoD to identify where they are buying well and determine the right mix of on-site support to help their buyers and contracting officers. These analyses will form the basis of the kind of strong measurement program the DoD requires if it is to continuously improve its acquisition or buying processes. Despite numerous calls for reform and commercialization of its activities over the last three decades, the DoD's leadership has little understanding of how effective their buying processes are in relation to the commercial sector.

Parts "Scandal" That Emerged on March 18, 1998: This research is especially important today because it represents the DoD's buying performance before the policy changes associated with the Federal Acquisition Reform Act of 1996 (FARA) were implemented. Today, DoD buyers and contracting officers are prevented from collecting certified cost and pricing data on purchases below $500,000 or on commercial items. The definition of a commercial item was also changed to allow any item that is found in a commercial catalog available for sale to the public to be defined as a commercial item, even if that part has little or no commercial customer base and is found only in militarized systems. The DoD is now re-evaluating these changes in light of the emerging parts "scandal."

For several months the DoD Inspector General's office has been coordinating this emerging "scandal" with the DoD's leadership. On the surface it would appear these were anomalous purchases; however, the behavior of the two publicized firms, Boeing and Sundstrand, as well as others currently under investigation by the DoD IG but not yet public, is more troublesome.[4] These firms took parts bought by the DoD as militarized parts for the last 10 to 15 years or more, placed them in a commercial catalog, even though commercial customers comprise little or none of the market for many of the parts, and then raised the prices precipitously in nearly every case. The DoD's buyers, in some cases discouraged and others prevented from collecting cost and pricing data on these "commercial" items, took their leadership's guidance at face value and awarded the contracts using commercial catalog prices.

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[4] Personal interview with DoD Inspector General staff on March 19,1998.

Specific examples of the egregious purchases can be found in the March 18, 1998 testimony of the DoD's Inspector General, Eleanor Hill, before the Senate Subcommittee on Acquisition and Technology, Committee on Armed Services. Ms. Hill stated that the DoD paid on average 280 percent more than fair and reasonable prices ($4.5 million cost increase) on one contract, 30 percent more than fair and reasonable prices on another contract ($1 million cost increase), and 172 percent more than fair and reasonable prices on three other contracts ($3.2 million cost increase) [Hill Testimony, 1998]. Ms. Hill provided anecdotes from other contracts indicating price increases of individual parts ranging from 1,430 percent for 108 electrical bells ($46.68 to $714) to 13,163 percent for 187 setscrews ($0.57 to $75.60) [Hill Testimony, 1998]. The fairness and reasonableness of the prices were determined using the cost and pricing data the DoD collected only two years ago for those very same parts.

This is not, however, a case in which the DoD's buyers are completely innocent. Though both industry and the DoD's buyers followed the letter of the new law, the buyers had other tools at their disposal. Most of these purchases were made by a Defense Logistic Agency (DLA) buying unit that should have recognized the dramatic price increases and demanded full and open competition for the purchases where multiple suppliers existed and the collection of some form of cost and pricing data on the purchases where only one supplier existed (sole source provider). Many of these parts were formerly purchased by the Air Force and bought efficiently using competition and cost and pricing data up until two years ago when these components were transferred to DLA in the name of acquisition reform and streamlined purchasing. In fairness to the buyers, industry would have undoubtedly complained at requests for cost and pricing data and senior DoD purchasing officials would not have been supportive of their buyers since "commercial" components were available.

The latest parts "scandal" highlights the need for careful measurement and the exercising of judgment in the collection of cost and pricing data. Furthermore, the definition of a commercial item should revert back to its former incarnation, where a commercial item was a product that was sold in significant quantity in the commercial sector. In the past, a contracting officer was also allowed to exercise judgment in the determination of whether an item was truly commercial. The former deputy

DoD Inspector General, Derek Vander Schaaf, predicted in 1995 predatory industry behavior should the sort of changes embodied in FARA of 1996 be passed into law:

> "The companies and even some DoD officials state that if you eliminate TINA and auditor oversight, then the DoD can buy their DoD-unique items from contractors at lower prices. Well, if you believe that you will generally receive a better price by eliminating the right to ask for cost and pricing data or the opportunity for auditors to look at a contractor's records, then I have a bridge you will be interested in." [Vander Schaaf Testimony, 1995]

The most important irony of this latest "scandal" is that it indicates today's operational commanders are paying more for their spare parts than they were two years ago; thus, they will have less to spend tomorrow on the modernization of their weapon systems. The FARA of 1996 was suppose to save money in order to provide the operational commanders with more funding for weapons. The operational commanders should demand a thorough and open accounting of this "scandal" from their counterpart acquisition leaders and their partners in industry.

1.3 Overview of Dissertation

This dissertation opens by examining the literature on DoD purchasing of commodities. This record is sparse, although a variety of experts have argued for more than 20 years that the DoD needs to buy greater amounts of commercial goods using commercial practices. The discussion of research is organized according to methodological flaws used in the past when assessing the DoD's purchasing performance. Very little systematic data collection and analysis is found in the literature; nevertheless, an extensive literature on defense procurement exists. Two novelties of this survey are the re-evaluation of the largest existing sample in the literature, producing some unexpected, contradictory findings, and the insertion of a previously unpublished sample of commodity purchases highlighting how overcharges arise and, at least in this particular case, the DoD establishment reacts to remedy the situation.

The approach to data collection and analysis is then presented, revealing the factors that affect the price of a commodity and ultimately the cost of a purchase by the DoD. Significant attention is devoted to introducing and explaining the unweighted and weighted price difference analysis methods, including the presentation of an example analysis. The weighted price difference

approach is important in light of one of the key weaknesses identified with past research: mere price comparisons neglect the representativeness of a purchase within the larger body of actual purchases.

The next three chapters present the findings from the electronic, engine, and software commodity sectors. Several unique analyses are performed on the electronic data: 1) price difference analysis, 2) stratification of the data to determine important constraints affecting price, 3) regression analysis to evaluate constraints affecting price, and 4) sensitivity analysis to evaluate the robustness of the findings within the sample. Several case studies are presented following the engine sector data analysis. These case studies consider the costs of DoD buying; thus, they more accurately portray the DoD's true costs when purchasing commodities.

Each chapter closes with a discussion of the important features of the analyses. For example, the software sector possesses unique traits, such as the use of incentives by the commercial suppliers to enhance an offer, that one does not see in the other sectors. By the time a software product makes it to market, the marginal cost of "manufacturing" more of that product is essentially zero. This phenomenon causes sellers to employ creative strategies to open, penetrate, and then dominate a market.

The final analysis chapter consolidates the purchases from each sector and assesses the DoD's overall performance relative to the average commercial sector organization. Analyses performed on each sector are repeated for the entire sample. Summary analyses comparing the relative performance of each sector against the other are performed to investigate whether the sector findings are mutually consistent with this research's central proposition. A series of scatterplots are presented at the end of the chapter highlighting the DoD's purchasing behavior: DoD's buying performance increases as the total contract value increases.

The dissertation closes with a discussion of the prospects for future research. Several important prospects are examined, but perhaps the most valuable is an examination of the commercialization of labor within the DoD. The DoD is presently engaged in a flurry of outsourcing of labor with little rational analysis guiding the trade-offs across all DoD labor categories as well as the potential ancillary impacts on the DoD's primary or war-time mission.

2.0 Previous Research

This chapter reviews the literature on defense purchasing that specifically compares the defense and commercial sectors. Considerable research has been undertaken to understand the economics of defense contracting as well as case studies related to major weapon systems development; however, very little of what could be termed research has specifically sought to compare purchasing in both sectors. The vast majority of knowledge of defense versus commercial sector purchasing rests on a fragile bed of anecdotal evidence provided through articles and pamphlets prepared for the general public. Very little scholarly writing has been done on this subject. This chapter will examine the problems plaguing past studies as well as introduce new analyses of existing data that highlight further problems with past research. The specific problems that have plagued past research are organized into these categories: skewed analyses, reliance on non-random samples, reliance on unweighted price comparisons, failure to provide or consider contextual information, or failure to analyze DoD's internal management and oversight costs.

2.1 Skewed Analyses

Some past studies [Angier, White, and Horowitz, 1979; and Coopers & Lybrand/TASC, 1994] have skewed the analysis of their data to support the thesis of their research. The study by Angier *et al.* is problematic: it is the most thorough comparison of purchasing of commercial and military products found in the literature, but it employs an analytic technique that omits the commodities where DoD buying using military specifications yields better prices. By omitting contrary data they had gathered, the researchers reach the obvious conclusion that buying commercial products offers the DoD enormous savings.

Angier *et al.* sought to show that the DoD could save money by abandoning military specifications and suppliers and buying directly from the commercial sector. The researchers identified one or more commercial suppliers for 40 commodities drawn from a Marine 105mm Howitzer battery's Table of Equipment. The data are presented in Table 2. The quantities identified in Column V of Table 2 are the quantities purchased on an annual basis by an individual battery.

Several products had two or more commercial suppliers, so the identified commercial price in Column III represents the average price for those suppliers of that product. The price in Column IV is the lowest price provided by a commercial supplier for that item.

The omission of items that cost less using conventional DoD suppliers and specifications is significant. Angier *et al.* based their conclusions on a method of analysis that used only those products found in Table 2 where the commercial price was less than the military price. The weakness of this approach is apparent once all products in Angier *et al.*'s sample are considered: using the average commercial prices, the DoD's total cost is less than the commercial cost. As part of this research, the prices and quantities provided by Angier *et al.*, Columns II and V of Table 2 were multiplied and the resulting products summed, yielding a total yearly "DoD" expenditure of $43,027.89. Similarly, each value in Column III was multiplied by the annual purchase quantity in Column V of Table 2 and the resulting products were summed, yielding a total yearly "commercial" expenditure of $45,823.86. This means that if each marine howitzer battery began following Angier *et al.*'s guidance of buying only commercial commodities, then for those 40 items the DoD would pay an additional $2795.97. The researchers were able to show potential savings through commercial buying by omitting those purchases from the sample that offered better prices using DoD specifications.

A different finding is produced if one assumes the commercial price is that of the lowest priced item for each commodity. If the lowest commercial price is used, multiplying Columns IV and V and summing the products, the total commercial cost would be $41,921.28. In this case, buying strictly commercial would save the DoD approximately $1100 for the 40 commodities. The problem with this assumption is that Angier *et al.* suspected and even identified several cases where the commercial items were not really comparable to the DoD items. One significant example is the sleeping bag. Not only are the commercial bags smaller and of questionable durability, but the authors discounted the prices by 40%, using the assumption the DoD would get a better price from the manufacturer. Within Angier *et al.*'s sample, this assumption was made only with the sleeping bag and mattress. Without

Table 2. Summary of Commodity Price Comparisons by Angier *et al.*

I	II	III	IV	V
	Prices			
		Commercial		
Commodity	DoD	Average	Lowest	Quantity
Wristwatch	23.67	27.70	17.50	18
Stopwatch	42.89	31.71	27.50	2
Clothing-drawer	6.25	5.63	2.25	252
Clothing-undershirt	7.45	5.63	2.25	252
Pneumatic Impact Wrench, 3/4"	379.00	364.00	200.00	1
Electric Typewriter	544.50	760.00	760.00	1
13" Manual Typewriter	211.65	175.00	175.00	1
Fire Extinguisher-15 lbs. CO2	76.00	73.75	66.50	6
Fire Extinguisher-10 lbs. Dry	54.67	26.00	24.00	23
Combination Padlock	19.90	7.00	5.50	2
Pin and Tumbler Padlock	1.50	0.75	0.75	6
Compass M-2	70.10	70.15	70.15	10
Compass Lensatic	17.57	14.83	8.00	13
Sleeping Bag	59.00	48.54	42.30	126
Mattress, pneumatic	13.40	11.25	7.20	126
Blanket	15.10	8.62	8.25	252
5-ton Automotive axle stand	17.84	50.75	50.75	12
4-ton Hydraulic jack	243.00	368.75	280.00	2
Truck wheel lift	312.00	451.00	451.00	1
4-ton Hydraulic hand jack	16.84	34.00	32.00	3
Tent Command Post	744.00	900.00	900.00	5
Tent, maintenance shelter	2614.64	1900.00	1900.00	1
Tent, fly, storage	54.00	240.00	240.00	3
Tent, general purpose	1116.80	950.00	950.00	4
Tarpaulin, 14 x 6	35.20	27.50	20.00	8
Tarpaulin, 26 x 22	120.00	155.00	155.00	2
Wet weather parka	13.90	8.00	8.00	126
Cold weather coat with hood	29.40	70.00	70.00	126
Liner for coat	8.90	27.00	27.00	126
Overalls, wet weather	13.30	8.00	8.00	126
Portable Electric Drill, 1/2"	64.00	133.33	110.00	1
Right Angle Electric Drill, 1/4"	137.00	70.00	70.00	1
Paste form soap grit	1.05	1.28	1.28	10
General Purpose Detergent	4.60	3.57	3.16	6
6 volt lantern	6.86	4.67	4.00	4
Siren, hand operated	98.75	210.50	210.50	1
Vacuum cleaner	167.89	138.94	138.94	1
Men's cotton coveralls	16.40	18.00	18.00	12
Mitten, Heat Protective	3.48	3.09	3.09	12
Suitcase, center folding	49.10	68.00	68.00	15

that assumption, the DoD would have been the more effective buyer by approximately $1000 over the entire sample. Consistently using the commercial products with the lowest price would not have provided the DoD with products of quality comparable to that produced using their traditional purchasing practices.

The Coopers & Lybrand/TASC [1994] study, commissioned by former DoD Secretary William Perry in 1994, took a different approach to arrive at whether there are differences between the commercial and defense purchasing sectors. This study was focused on firms that develop and build defense systems, with some of the firms manufacturing comparable commercial products. The study sought to identify the premium the DoD pays industry to accommodate the DoD's regulatory practices. This study recognized that comparing only price differences fails to consider the possibility of hidden regulatory costs in doing business with the DoD. Using 10 case studies, the study concluded that the DoD pays an average 18 percent premium on value-added costs as a result of excessive or dysfunctional DoD regulation [Coopers & Lybrand/TASC, p. 47]. Value-added costs are equal to a firm's total cost less material purchases [Coopers & Lybrand/TASC, p. 4]. The Coopers & Lybrand/TASC study, however, has some limitations because of a weak sampling mechanism and the skewed manner in which cost information was collected.

The case studies gathered as part of the Coopers & Lybrand/TASC study were built using interviews with cost center managers from the participating firms. DoD oversight personnel were excluded from the interview process. Using a structured interview technique, the research team systematically identified the processes, subprocesses, and activities of each cost center. The interviewees were asked to identify specific cost drivers resulting from DoD regulation and oversight and make suggestions for reducing regulatory compliance costs. Once a process model for the site was built by the researchers, the cost center managers were asked to estimate savings should DoD regulations and oversight suddenly disappear. The integrity of the researchers' data is dependent upon whether the cost center managers understand the differences in engineering and managing a program with or without DoD regulations and oversight, assuming such differences

exist. The study provides very little information showing how responses were translated into percentages of value-added cost attributable to regulatory compliance.

The weakness of the researchers' methodology becomes apparent once the scope of the interviews is examined. The researchers relied on opinions of managers of defense products rather than other empirical evidence that was immediately at their disposal. Six of the ten sites the researchers visited had parallel commercial operations. The strictly commercial operations offered a counterfactual basis of comparison. However, the strictly commercial operations were ignored. The researchers chose to stay with product lines that were either defense or a mix of defense and commercial business. The strictly commercial, identical product lines could have provided a reliable counterfactual basis of comparison for determining the validity of the opinions from cost center managers of defense projects.

A further weakness is the study's examination of only the cost side of a cost/benefit analysis. Benefits of DoD regulation and oversight were not considered. Many in industry and DoD have extrapolated from the study to assume that DoD oversight personnel add no value. The study provides no evidence on this issue.

2.2 Reliance on Non-Random Samples

Many studies rely on small, unrepresentative samples to argue superiority of commercial sector behavior [Mandel, 1977; Michelli, 1977; Stimson and Barnett, 1980; Gansler, 1982; Comeau, 1984; Stewart, 1986; Senate Report 101-62, 1989; CSIS, 1991; and Coopers & Lybrand/TASC, 1994]. This section examines two of those studies.

One of the most illustrative studies relying on a non-random sample was performed by Stimson and Barnett [1980]. The intent of this study was to compare products bought using commercial rather than military specifications. Commercial specifications are often advertised as being focused on performance. Specifications used by the DoD usually not only address performance, but they also specify how a good is to be manufactured and tested, sometimes to

absurd levels of detail and standards of evaluation.[4] Issues of reliability and durability were not discussed for the commercial equivalents, nor were purchase quantities for each item identified. The authors found problems with both approaches and no real differences in terms of price. With such a small, unrepresentative sample and no purchase quantities, it is impossible to argue for or against greater usage of commercial components. Found in Table 3, the 13 items do not appear representative of DoD commodity purchasing. First, no quantities are provided. Second, the nature of the items appear more relevant to a hotel and its restaurant rather than a military unit.

Table 3: Summary of Commodity Price Comparisons by Stimson and Barnett [1980].

Commodity	Prices		Percent Difference
	DoD	Commercial	
Conduit, one inch	$2.17	$2.20	-1
Rubber gloves	$19.87	$24.99	-26
Bed sheet	$3.59	$3.48	3
Drawers	$1.01	$0.94	7
Worcestershire sauce	$10.07	$8.01	26
Powdered sugar	$0.28	$0.28	0
Cap screws	$1.38	$1.53	-11
Aluminum sulphate, bag	$13.92	$9.00	55
Towels	$1.46	$1.12	30
Undershirts	$1.18	$0.90	31
Cloth gloves	$2.35	$1.81	30
Fireman's boots	$23.79	$20.00	19
Protective shoes	$17.92	$15.60	15

Another set of comparisons is provided primarily by Gansler [1982], though some of the cases were drawn from previous research [Gansler, p. 280]. This set of comparisons differs from the previous sets in that each item is far more sophisticated technically than anything appearing in Tables 2 and 3. The items found in Table 4, drawn from anecdotes from several researchers, are

[4]The DoD's penchant for overspecification are legend. Until recently, the specification for glass ashtrays exceeded 20 pages. This included directions for a shatter test, ensuring that the product would break into no more than "X" pieces upon shattering. The Army's specification for chocolate chip cookies was no less detailed. It included a specification for the minimum number of chocolate chips each cookie must contain. This type of DoD behavior is to be expected when the buyers have generally, in the past, been unable to reward good past performance with more government business. One must resort to a detailed specification to receive the minimum quality required by the DoD.

sophisticated electronic components, some of which would qualify as consumer electronic devices. An item by item comparison indicates the DoD is paying significantly more for these pieces of equipment than the commercial sector. Gansler [1982] concludes that buying commercial equipment is "usually much cheaper."

Table 4: Summary of Electronic Component Price Comparisons by Gansler and Others.

Commodity	Prices		Percent Difference
	DoD	Commercial	
Army aircraft radio receiving set[3]	$6000	$1300	362
Army aircraft distance-measuring set	$15,000	$4000	275
Shipboard tape recorder[3,4,5]	$8000	$167	4690
Shipboard telephone[3,4]	$70	$42	67
Aircraft video tape recorder[3,5]	$7000	$2500	180
Diesel generator set to replace turbine sets	$56,000	$14,000	300
16mm motion-picture projector	$1200	$600	100
Shipboard navigational system	$115,000	$27,000	326
Frequency Agile Signal Simulator[6]	1,000,000	200,000	400

Sources: [3]Gansler, 1982; [4]Mandel, 1977; [5]Michelli, 1977; [6]CSIS, 1991.

The problem with Tables 3 and 4 is that the samples are so small that more general conclusions may not be drawn. These items could be outliers or representative of all buying, but those insights are not provided by the researchers. On the surface, many of these purchases appear problematic, but one cannot draw conclusions without a full understanding of the circumstances, including understanding whether these purchases are the exception rather than the rule. The researchers want you to believe in the benefits of commercial buying based on less than two dozen items out of over 15 million contracts the DoD was writing on a yearly basis at that time.

2.3 Reliance on Unweighted Price Comparisons

Most past research also suffers by relying solely on unweighted price comparisons [Mandel, 1977; Michelli, 1977; Stimson and Barnett, 1980; Gansler, 1982; Comeau, 1984; Stewart, 1986; Senate Report 101-62, 1989; CSIS, 1991]. Issues related to lot size or the volume of buying are typically ignored. Tables 3 and 4 provide illustrations of this type of analysis. This approach

assumes all products are purchased with equal frequency, an assumption that may be inconsistent with typical DoD buying. Another facet of the representativeness problem is how well a group of products, for example aircraft engine parts, are representative of all products bought by the DoD. By ignoring the purchase quantities within and across product sectors, a researcher is saying that bottles of Worcestershire sauce and shipboard navigational systems are equally representative. So, representativeness manifests itself as a problem more than once in this type of research.

The volume or quantity of a buy is an especially important consideration because it can completely change an analysis, leading to different interpretations of the results. The re-analysis presented earlier using all of Angier *et al.*'s data illustrates this phenomenon. Once all products and purchase quantities were considered, using the average commercial prices, the DoD was shown to be the better buyer by approximately $2700 across the 40 products.

2.4 Failure to Provide or Consider Relevant Contextual Information

Another common feature of past research is the lack of contextual information to ensure items bought by each sector are fairly compared [Mandel, 1977; Michelli, 1977; Stimson and Barnett, 1980; Gansler, 1982; Comeau, 1984; Smith *et al.*, 1988; Rich and Janos, 1994; and Coopers & Lybrand/TASC, 1994]. Background or contextual information consists of various product characteristics that may be relevant in a comparison as well as the circumstances under which a product is to be used. For example, whether a computer processor board is intended for an office computer as opposed to a fighter aircraft is highly relevant, for the power and vibrational requirements in an aircraft are significantly different. Contextual information is required to understand whether identical items are being compared and whether there may have been some extenuating circumstances explaining a dramatic price difference between the two sectors.

The comparisons provided by Gansler in Table 4 provide some examples of this phenomenon. Specifically, during the 1970s, video tape recorders were bought by the thousands in the commercial sector. However, the number of aircraft requiring video tape recorders is significantly smaller. A small number of aircraft translates into a smaller number of video tape

recorders to amortize fixed development, engineering, and manufacturing costs. Furthermore, the electronics and environmental characteristics of an aircraft are significantly different from those in the home or workplace. Quite probably, there were engineering costs associated with retrofitting a video tape recorder to an aircraft further driving up the fixed costs. A smaller manufacturing base for amortizing fixed costs translates into higher unit costs. Comparing an off-the-shelf item to one that goes into a jet aircraft is not an appropriate, identical comparison.

Gansler's sample provided in Table 4 also contains another good illustration of why contextual information is important. A curious comparison is a shipboard tape recorder for $8000 versus a $167 dollar commercial recorder. The $8000 shipboard tape recorder may be a large logging tape recorder used to record communications traffic or sonar data that has been ruggedized to withstand the typically rough power and environmental conditions of an ocean-going vessel. No contextual information was provided to ensure identical items were being compared. Without relevant contextual information like political, engineering, or environmental considerations, direct price comparisons of components are often meaningless.[5]

The importance of contextual information is highlighted with the Frequency Agile Signal Simulator that is provided in Table 4. The Frequency Agile Signal Simulator appears particularly egregious since the DoD paid $1 million for an item commercially-available for $0.2 million. Available contextual information paints a far bleaker picture. The DoD's system is actually a customized, vastly inferior variant of the commercial system [CSIS, p. 21]. Furthermore, at that time the DoD could not purchase the commercial variant without either certified cost or pricing data or evidence of "market acceptability." Since it was a new product, the contractor could not demonstrate market acceptability, and the company was unable and unwilling to provide certified cost or pricing data [CSIS, p. 21]. The market acceptability requirement, without the allowance for

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[5]Even political considerations may enter into the price of equipment. The C-130 cargo aircraft, for example, is **required** to have a piece of its fuselage manufactured in West Virginia and then shipped by rail to Lockheed's main assembly facility in Georgia. Considering Lockheed's excess capacity in Georgia, this cannot be efficient. Many large system procurements proudly display maps of the United States annotated with the number of suppliers in each state supporting the procurement. These maps are further broken down within each state to show numbers of suppliers and dollars flowing to each congressional district. These maps help ensure congressional support rather than cost efficiency for a program. Spinney [1985] has labeled this practice "political engineering."

judgment by the DoD buyer, is one of the perverse consequences of the DoD's past rigid and unrealistic definition of a commercial product.

The Frequency Agile Signal Simulator anecdote reveals the possible public policy implications of product comparisons and their results. The contextual information introduces a host of other issues vastly more important to public policy researchers than a mere price difference. The context revealed that the DoD's regulations may be too rigid to recognize new products as commercial products. Since the DoD could not define the product as a commercial item, they required certified cost or pricing data. The manufacturer, operating a commercial business, could not and would not provide it. Consequently, they developed a technically inferior variant at a higher cost to satisfy the DoD's requirement. The context or background information from this procurement provides some understanding of why the DoD may be less efficient than the commercial sector. Understanding how this occurred could lead to public policy remedies.

The work by Comeau in the early 1980s presented some of the strongest evidence available that the DoD pays more for an item than the average commercial sector organization. Comeau collected many of the overpricing anecdotes provided by the media in the early Eighties into a pamphlet. Unfortunately, Comeau compared some commercial items to "phantom" items the DoD never purchased. For example, Comeau identified a 12¢ allen wrench as being purchased by the Air Force for $9600 [Comeau, p. 6]. This price was drawn from a contractor's unnegotiated estimated price list. The Air Force never bought this item at that price and did not enter negotiations with the contractor to even discuss the part [Air Force Logistics Command, p. 4]. In Comeau's first sample of 31 products, seven fit the category of never purchased.

Nevertheless, Comeau as well as Fitzgerald [1989] provided strong evidence that some spare parts were being purchased at exorbitant prices in comparison to their commercial sector price. The remaining 24 items from Comeau's sample of 31 show significant overpricing, but no quantities were provided nor insight revealing whether these were isolated incidents or typical purchases. At the time and through to the late Eighties, the alleged culprit was the DoD's "average pricing" policy [Fairhall, 1987; and Fox and Field, 1988]. The theory behind the average pricing policy is that all

engineering, manufacturing, management and administrative overhead, and profit are averaged equally over the goods in a pool of equipment bought by the DoD from an individual manufacturer. Consequently, expensive items or systems receive disproportionately small allocations of overhead while minor support equipment or parts receive disproportionately large portions of overhead, producing what sometimes appears to be absurdly priced products. Unfortunately, this average pricing policy had no basis in reality. In the early Eighties, there was no consistent DoD policy for industry to follow in the allocation of overhead. Fitzgerald [1989] analyzed numerous overpriced part examples and could find no consistent process or procedure for allocating overhead being followed by industry. Finally, in a January 15, 1985 memorandum from the Air Force's chief of procurement, General Robert D. Russ stated that there was no substance to the "equal allocation of overhead" or average pricing theory, that "all of the contractors over which we have cognizance use some measure of direct effort as a basis for allocating costs." [Fitzgerald, 1989, pp. 174-175] Thus, General Russ revealed that the DoD had no real policy for industry to follow in the allocation of costs (e.g., engineering effort, overhead, and profit).

Included in Comeau's study was the infamous $436 hammer. In actuality, the DoD paid only $7 for a hammer that cost $17 commercially [Comeau, Appendix B]. The contractor then allocated a plethora of overhead and other costs to arrive at the $436 cost. It was also apparent that the hammer purchase was part of a larger purchase of a spare parts package associated with some engineering effort. The contractor was not the DoD's supplier of hammers.

Comeau and the media should have taken issue with the allocation of other costs rather than the mere price of the hammer. Comeau's examination should have focused on whether the allocation of overhead costs were justified. If the other costs were justified, then it should not have mattered how they were allocated unless the delivery prices for the spare parts were going to be used to support future spare part procurements. No evidence of the latter possibility was presented.

The tragedy of the early Eighties spare parts scandal is that no researcher systematically collected data resembling a random sample of DoD purchasing. Were the overpriced parts from a few unscrupulous manufacturers or was it systematic across industry? Because no systematic

evidence exists, we have no idea what to conclude. There is no reason to believe the examples presented by Comeau and the media are anything more than anomalies.

The overpricing scandals from the early Eighties led to public policy decisions that could adversely affect the actual price the DoD pays for a part. One new policy arising from the spare parts scandals required DoD buyers to negotiate prices down to the item level. This led the DoD to hire thousands of procurement specialists and contracting officers. A hidden cost of DoD purchasing is the labor costs associated with a purchase. For example, immediately following what emerged as the "spare parts scandal" in the early Eighties, the Air Force hired nearly 1000 new contracting officers to implement the DoD's new commodity pricing practices [Air Force Logistics Command, p. 13]. Since the DoD's contracting labor costs rose substantially during this period of time, it is quite possible the DoD began paying more in the aggregate for parts following the scandal. Industry also had to hire more people and expend more time to negotiate contracts down to the item level. This highlights a likely unintended consequence of poorly designed and then politically-abused research.[6]

2.5 Overlooked DoD's Management and Oversight Costs

More recent attempts at research on defense procurement have focused on determining the regulatory burden the DoD imposes on industry [Smith *et al.*, 1988; CSIS, 1991; and Coopers & Lybrand/TASC, 1994]. These attempts are noteworthy for taking unique approaches for studying DoD procurement, but each joins previous studies of defense procurement by not considering the DoD's direct internal program management and oversight costs along with their indirect effects. These costs are real and should be considered in the cost the DoD pays when purchasing a commodity. All relevant studies reviewed make the implicit assumption that the DoD's direct costs are free.

[6]The other issue it highlights is how weak the research methods are that fail to consider the government's internal purchasing costs. This issue is addressed in detail later by this dissertation's case studies.

Smith *et al.* investigated the regulatory activities of DoD. In theory, this represented a significant innovation by attempting to capture a portion of the regulatory burden industry must sustain when doing business with the DoD. In practice, however, the researchers used a very narrow definition of regulation, confining themselves to the activities of congressional staffers, DoD auditors, and various requests for information the DoD receives from the legislative branch. This narrow focus limits the study.

No part of the study examined specific acquisition programs or the DoD personnel conducting oversight for the programs, either in the plants or in DoD system program offices. The study also did not attempt to identify any regulatory effects DoD acquisition personnel may impose on industry. The study was performed at a macro-level with respect to procurement, focusing on the numbers of auditing personnel and requests for information by fiscal year from various agencies of government.

Smith *et al.* concluded that there is little unambiguous, documented evidence that the current regulatory environment has debilitating effects on acquisition programs. Furthermore, the study found no evidence that regulatory activities affect the performance or quality of a final product, either favorably or adversely [Smith *et al.*, pp. v-vii]. The conclusions, however, are not consistent with the research findings or methods.

The study fails to support its conclusions most glaringly with respect to quality and performance. The researchers collected no data related to quality or system performance, rather they used an unorthodox measurement, individual procurement cycle time, as a surrogate for quality and performance. Procurement cycle time is the length of time to take a weapon system from concept to operational use. Using their sample of programs, they found no evidence that procurement cycle times have increased over the last 35 years [Smith *et al.*, pp. 18-20]. This is an astonishing finding, for the consensus of virtually all other research is the precise opposite [Spinney, 1985; Weider and Gertcher, 1987; and Spinney, 1995]. Spinney, an analyst in the DoD Secretary's office of Program Analysis and Evaluation, has cogently demonstrated growth in procurement cycle times using the DoD's very own procurement data.

Another weakness of the study is the increasing hidden cost of Congressional or DoD Inspector General inquiries. Inquiries are answered using DoD and industry acquisition program office personnel. The regulatory burden a staffer or auditor may impose cannot be measured unless one examines the effects of an individual or an "average" inquiry. No attempt is made by the researchers to arrive at the cost in dollars or labor hours for the average congressional inquiry. For example, a call from a staffer for the chairman of the Senate Armed Services Committee requesting information about a hypothetical acquisition program will result in numerous phone calls to various generals and colonels until the DoD's program manager is finally reached. The program manager will then call the contracting firm and that firm must commit resources to answer the senator's question, even at the expense of delaying work on the respective program. In parallel, the contracting firm's lobbyist(s) has also been contacted and is working the question down a separate personnel chain. Depending upon the issue, there may be two answers, one for each chain of command or one for public and private consumption. By ignoring these costs, Smith *et al.* overlooks one aspect of the regulatory burden the DoD imposes on itself and industry.

The cost of a congressional or DoD inquiry can be very expensive. As part of the data collection for this dissertation, one DoD program office provided evidence of this expense. This procurement is one of the DoD's large, unprecedented acquisitions valued at more than $10 billion over its procurement cycle. This acquisition program faced 875 inquiries in 1994 and 474 during the first five months of 1995, with the average 1994 inquiry taking over 2.5 program office staff hours to complete. This equates to almost one person working full-time to answer the questions, although the program office had two individuals assigned on a part-time basis to staff and answer the inquiries. The program office also developed a tracking system to help organize and manage the inquiry process. These figures do not include the even greater impact on the developing firm, who must divert some of their energies to help answer the congressional inquiries facing the SPO.

The Coopers & Lybrand/TASC study focused solely on the cost of the DoD's regulatory activities. The use of only cost center managers without rigorous financial documentation and interviews with the lowest tier engineering and program management personnel leaves a lot of

unanswered questions. Low-level personnel could have corroborated or refuted the opinions of senior managers typically isolated from the day to day interactions with the customer. The DoD's on-site personnel costs were also not considered along with their associated benefits. The direct costs of DoD program management, such as DoD labor and infrastructure costs for program office personnel, were not considered along with their secondary effects arising out of interaction with their counterparts within each firm. The researchers provide no insight into how they separated the impact of DoD program management, inspector general staff, outside DoD auditors, and congressional staff inquiries from the activities of the DoD's resident contract administration staff.

By focusing on only one facet of defense procurement, alleged regulatory burden industry sustains, the researchers underestimate the ultimate cost to the taxpayer to sustain the DoD's oversight and regulatory activities. A proper comparison examines direct and indirect DoD oversight costs as well as the benefits of those activities.

2.6 An Illustration of the Benefits of DoD Oversight

This section examines the benefits of DoD oversight using an anecdotal sample of data as well as the associated analysis from the mid-Eighties that did not make it into the public record. Many of the anecdotes comprising the Comeau sample were instances where the system worked: the DoD's auditors, whose job it is to uncover and remedy legitimate overpricing, caught the potential overpricing and reported it to superiors, prior to media involvement. Another illustration of this phenomenon is found in a sample of engine parts bought in the mid-Eighties.[7] The sample is approximately 150 percent larger than any sample in the literature and certainly more representative of equipment bought by the DoD. This sample of data also represents an example of where the system worked. The network of DoD contract administration staff detected systematic overpricing involving spare parts associated with a jet engine.

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[7]This sample is unpublished. It was uncovered as part of the data collection activities for this dissertation. It was handed anonymously to me during a visit to a manufacturer along with associated documentation revealing that the material was the subject of a federal fraud investigation during the Eighties.

All of the parts were provided by suppliers, yet the DoD buys from the actual engine manufacturer or prime contractor. The DoD sometimes buys from the prime contractor to lower their contracting costs by not having to manage the purchase of thousands of parts. Under those circumstances, the DoD will pay handling or pass-through charges, but those charges should not be near the levels found in this sample. There is a trade-off between high overhead costs in managing thousands of small parts and paying handling charges to the prime contractor to perform that duty for the DoD.

The sample of data, found in Table 5, consists of 105 engine parts bought by an engine manufacturer from a variety of parts suppliers serving DoD and industry. For each part, three prices are provided. The first price, Original, found in the first column, is the price paid by a DoD buying office that uses the parts. The second price, Commercial, found in the second column, is the price paid by the engine manufacturer to a parts supplier. The last price, Negotiated, found in the third column, is the price the DoD eventually negotiated for each of the parts once the DoD's auditors detected the overpricing. Accompanying the prices are the quantity and total cost for each item using the three different prices (product of the quantity and each respective price). Some of the part names are abbreviated while others have no name. Some parts are listed more than once, but are actually different versions of the same type of part.

The final analysis is provided by summing the columns to determine what the DoD should pay as opposed to did pay. If the columns are summed, the total cost for the Original, Commercial, and Negotiated columns are $464,608, $60,524, and $43,287, respectively. The DoD paid more than ten times the total cost that was eventually negotiated for the parts. The DoD finally negotiated a set of prices below many of those paid by commercial firms.[8] Ironically, in the end, the DoD was never reimbursed for these overcharges because this sample became embroiled in a larger spare parts legal matter with this corporation that languished in the hands of the Justice Department and was eventually not prosecuted.

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[8]This odd result occurred because the prime contractor was also being overcharged by many of its suppliers. The DoD's auditors were able to reach into those organizations and stop that second tier of overcharging.

To fairly and reliably compare DoD purchasing performance with that in the commercial sector, research must: 1) compare identical items, 2) employ large samples from several sectors, and 3) consider hidden costs such as DoD oversight wherever possible. Previous research has failed to provide appropriate, reliable comparisons.

Table 5: Engine Parts and Pricing From Unpublished Sample

Commodity	Prices			Quantity	Original Total	Commercial Total	Negotiated Total
	Original	Commercial	Negotiated				
Tube Clamp	189.57	14.45	16.51	27	5118.39	390.15	445.77
Inner Tube	460.00	89.50	71.86	12	5520.00	1074.00	862.32
Load Ring	46.50	6.90	7.89	195	9067.50	1345.50	1538.55
Slip Ring	94.50	1.14	1.14	110	10395.00	125.40	125.40
Test Part	67.00	6.78	7.75	240	16080.00	1627.20	1860.00
Shoulder Stud	211.68	5.32	6.82	540	114307.20	2872.80	3682.80
Shoulder Stud	41.70	5.56	7.13	175	7297.50	973.00	1247.75
Machine Bolt	13.50	1.81	2.07	480	6480.00	868.80	993.60
Machine Bolt	23.01	3.59	4.10	250	5752.50	897.50	1025.00
Nozzle Retainer Pin	81.00	1.33	1.50	125	10125.00	166.25	187.50
Weight Balance	100.88	21.73	15.75	50	5044.00	1086.50	787.50
Laminated Shim	127.00	19.20	21.94	100	12700.00	1920.00	2194.00
Laminated Shim	148.00	8.40	9.60	100	14800.00	840.00	960.00
Local Manifold Tube	1080.00	163.00	186.29	5	5400.00	815.00	931.45
Fuel Seal	108.91	5.35	4.80	195	21237.45	1043.25	936.00
O-Nut	96.90	18.33	16.49	100	9690.00	1833.00	1649.00
Anti-Icing Air Tube	948.83	153.50	143.12	12	11385.96	1842.00	1717.44
WGT	203.00	8.90	16.19	55	11165.00	489.50	890.45
WGT	203.00	8.45	10.84	50	10150.00	422.50	542.00
Spacer	83.83	5.97	6.75	50	4191.50	298.50	337.50
Clip	69.89	9.00	10.66	30	2096.70	270.00	319.80
No Name	804.00	101.00	116.12	4	3216.00	404.00	464.48
Bracket Angle	23.76	2.62	2.99	40	950.40	104.80	119.60
Nut	65.48	6.98	7.98	27	1767.96	188.46	215.46
Ret Strap	46.50	6.75	7.71	40	1860.00	270.00	308.40
Ret Strap	44.42	6.75	7.71	40	1776.80	270.00	308.40
No Name	406.93	6.75	51.08	5	2034.65	33.75	255.40
Seal Tube	360.00	35.53	42.42	8	2880.00	284.24	339.36
Ret Lower	163.19	52.95	19.62	29	4732.51	1535.55	568.98
Ret Ignition Seal	114.00	52.95	15.97	12	1368.00	635.40	191.64
Ret Lower	114.00	52.95	14.06	12	1368.00	635.40	168.72
No Name	9.25	1.00	1.19	118	1091.50	118.00	140.42
Seal Igniter	263.00	33.22	39.70	11	2893.00	365.42	436.70
No Name	48.83	9.15	8.57	30	1464.90	274.50	257.10
No Name	49.95	8.70	9.94	35	1748.25	304.50	347.90
Nipple Tube	74.59	8.85	10.48	19	1417.21	168.15	199.12
Fitting	42.00	4.92	5.45	76	3192.00	373.92	414.20
Bolt Shear	27.50	0.88	1.06	55	1512.50	48.40	58.30
Bolt	18.63	0.70	0.90	100	1863.00	70.00	90.00
Elbow	130.00	8.90	11.41	5	650.00	44.50	57.05
Nipple	63.18	9.37	10.50	28	1769.04	262.36	294.00
Bolt Mach	43.88	3.66	4.18	50	2194.00	183.00	209.00
Bolt	9.15	0.50	0.59	100	915.00	50.00	59.00
Bolt	8.95	0.75	0.86	200	1790.00	150.00	172.00
Machine Bolt	7.54	0.94	0.91	110	829.40	103.40	100.10
Machine Bolt	5.81	0.94	0.91	240	1394.40	225.60	218.40
Bolt	10.93	1.18	1.35	135	1475.55	159.30	182.25
Bolt	38.00	1.78	3.21	46	1748.00	81.88	147.66
Bolt	43.73	1.78	3.21	80	3498.40	142.40	256.80
Bolt	26.00	0.69	0.79	70	1820.00	48.30	55.30
Bolt	12.79	0.80	2.08	70	895.30	56.00	145.60
Bolt	6.21	1.14	0.48	525	3260.25	598.50	252.00

Commodity	Prices			Quantity	Original Total	Commercial Total	Negotiated Total
	Original	Commercial	Negotiated				
Bolt	8.72	1.07	1.05	290	2528.80	310.30	304.50
Bolt	20.78	1.01	1.15	60	1246.80	60.60	69.00
Bolt	9.83	1.50	1.71	240	2359.20	360.00	410.40
Bolt	9.78	0.84	0.42	150	1467.00	126.00	63.00
Bolt	13.46	1.46	1.03	120	1615.20	175.20	123.60
Load Ring	102.60	6.90	7.89	45	4617.00	310.50	355.05
Load Ring	121.72	6.90	7.89	30	3651.60	207.00	236.70
Shoulder Stud	21.43	4.89	5.79	160	3428.80	782.40	926.40
Neaded Pin	26.93	12.03	2.32	80	2154.40	962.40	185.60
Neaded Pin	26.94	2.17	2.41	139	3744.66	301.63	334.99
Tube Transfer	12.54	1.50	1.81	100	1254.00	150.00	181.00
Tube Transfer	38.30	3.28	3.75	44	1685.20	144.32	165.00
Retainer Seat	51.25	1.32	1.51	45	2306.25	59.40	67.95
Compression Spring	22.81	2.27	2.59	36	821.16	81.72	93.24
Compression Spring	48.75	2.79	3.19	24	1170.00	66.96	76.56
Shim	10.13	0.77	0.94	100	1013.00	77.00	94.00
Compression Spring	33.64	1.92	2.19	24	807.36	46.08	52.56
Compression Spring	21.40	1.38	1.58	48	1027.20	66.24	75.84
Compression Spring	39.00	2.90	3.31	32	1248.00	92.80	105.92
Compression Spring	51.60	4.30	4.91	24	1238.40	103.20	117.84
Compression Spring	34.83	1.50	1.71	36	1253.88	54.00	61.56
Compression Spring	146.17	6.70	9.94	11	1607.87	73.70	109.34
Spring	73.72	2.75	3.26	14	1032.08	38.50	45.64
Filter Screen	330.32	29.89	53.00	10	3303.20	298.90	530.00
Cover	60.80	5.95	6.80	16	972.80	95.20	108.80
Screw Cap	37.82	4.45	5.42	45	1701.90	200.25	243.90
Manifold Cover	49.00	5.95	6.80	64	3136.00	380.80	435.20
No Name	182.25	13.17	15.05	13	2369.25	171.21	195.65
Connector	231.00	43.86	40.98	6	1386.00	263.16	245.88
Tube	100.71	19.79	22.62	24	2417.04	474.96	542.88
Seat Local	20.25	3.37	3.85	56	1134.00	188.72	215.60
Plate Mounting	193.00	15.00	2.11	7	1351.00	105.00	14.77
Spring	35.37	2.40	3.20	49	1733.13	117.60	156.80
No Name	50.50	0.39	0.38	20	1010.00	7.80	7.60
Spacer	30.26	2.02	2.31	55	1664.30	111.10	127.05
No Name	56.49	16.75	19.14	22	1242.78	368.50	421.08
Bracket	31.72	450.00	5.43	42	1332.24	18900.00	228.06
No Name	48.60	2.27	2.69	45	2187.00	102.15	121.05
Bolt	27.75	1.08	1.38	79	2192.25	85.32	109.02
Clip	8.45	1.00	1.09	425	3591.25	425.00	463.25
Pin	13.50	1.85	2.11	72	972.00	133.20	151.92
Seal	4.19	0.29	0.26	225	942.75	65.25	58.50
Machine Screw	6.40	1.15	1.02	425	2720.00	488.75	433.50
Guide	11.80	2.05	2.26	200	2360.00	410.00	452.00
Guide	11.70	2.05	2.26	200	2340.00	410.00	452.00
Guide	45.90	3.25	3.89	65	2983.50	211.25	252.85
Guide	47.50	5.75	7.34	55	2612.50	316.25	403.70
Bolt	21.60	1.95	2.31	90	1944.00	175.50	207.90
Oil Tube	673.00	82.40	105.68	5	3365.00	412.00	528.40
Oil Tube Support	660.00	57.50	73.75	5	3300.00	287.50	368.75
No Name	47.50	5.66	6.70	60	2850.00	339.60	402.00
Bal Ingt	87.89	19.06	17.40	45	3955.05	857.70	783.00
Ring Ret Key	98.00	9.00	11.55	9	882.00	81.00	103.95
					$464,608.52	$60,524.20	$43,287.92

3.0 Approach to Data Collection and Analysis

This chapter presents the methods of analysis that are employed to test public sector beliefs about the purchasing efficiency of the DoD. Evaluating the purchasing efficiency of the DoD relative to the commercial sector in buying standard items or commodities requires a larger, more representative sample of actual purchases and more consideration of both price and non-price factors than previous research provides. Statistical analyses and case studies are employed to investigate the purchasing performance of the DoD relative to the commercial sector.

The DoD primarily buys services, systems, and spare parts. As was shown in Chapter One, most of the money in DoD procurement is in systems and most of the contracts deal with commercially available items. Spare parts are essentially commercially available items or militarized parts for a particular weapon system. For example, turbine blades for a fighter jet engine are not interchangeable with those of an engine on a Boeing 737; however, the DoD flies many other aircraft that use strictly commercial engines and spare parts. This chapter introduces the methods employed for data collection and analysis of commercially available items as well as the issues that affect one's ability to systematically collect and analyze DoD purchasing data.

3.1 Background on Items Purchased and Processes Employed by the DoD

System Program Offices (SPOs) are established to oversee the acquisition of large or militarily important systems. Smaller assemblies or subsystems of a larger system procurement are sometimes managed by a separate SPO. A SPO is a team of engineers, buyers, contracting officers, financial analysts, logisticians, and program management personnel focused on procuring a particular system or subsystem.

Commodities or spare parts are typically bought by the Defense Logistics Agency (DLA) or any one of the many DoD maintenance and supply activities. The purchasing offices are referred to as buying activities or depots. A sealed-bid process of some form is typically used to buy commodities. The SPO for a particular system will also procure the initial spares packages for their system. The initial spares package is typically comprised of all unique parts for that particular

system, some of which could be commercially available commodities. Parts used by that and other systems, or generic parts, are procured either by a DLA depot or one of the DoD's item managers. Commodities are goods that either exist on the shelf of a supplier or can be readily made according to either a commercial or DoD specification. All commodities considered in this analysis are bought by the military and commercial sectors. They must be identical products used by both sectors.

The procedures for buying commodities are quite different from those employed to procure systems. The military expresses its intent to buy a commodity in a Request For Quotation (RFQ). The DoD will then receive bids and award to the certified supplier offering the lowest price. At the time of the data collection, if the total value of the contract was less than $2500 and there were firms approved to sell the good to the DoD, then the contract was awarded automatically to the firm whose turn it was to receive the contract. The next time the DoD needed that good, the next firm on the approved list for that commodity was automatically awarded the contract. Human buyers handle all contracts over $2500 and, in some cases, smaller contracts. In many cases, however, the human buyer does not know what is being bought. This leads to some perverse contractual actions.[9]

A recent change in DoD buying behavior can be found in the distribution of what are essentially credit cards within organizations for small purchases. The cards are typically used for office, cleaning supplies, and local purchases of commercially available items less than $2500.[10] This change enabled the DoD to eliminate thousands of buyers, contracting officers, and supply personnel that previously did this buying for each operating activity.

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[9] As part of the data collection efforts for this dissertation, personnel specializing in commodity buying were interviewed. One particularly egregious anecdote uncovered is an o-ring purchase made several times a year from a small firm. Another goal of the DoD's commodity centers is the sustainment of small businesses. This particular small firm has a minimum buying policy of $30. However, several times a year they are called upon by the DoD to sell one 10-cent o-ring that any citizen could purchase in their local hardware store for 25 cents. The minimum buy policy drives the cost to the DoD to $30. The firm has asked the DoD buyer if they could send $30 worth of o-rings, but the DoD's buyer responds that it is not authorized since they have a demand for only one o-ring and no storage capacity.

[10] Within the Air Force, each major command sets the purchase limit for the credit cards and attaches limits to what can be purchased. The federal government calls them IMPAC cards, or International Merchant Purchase Authorization Card.

3.2 Factors Influencing Commodity Pricing

The previous chapter identified six factors of a purchase (see Figure 6) that might influence the price of a good: indirect oversight, direct oversight, packaging requirements, lot size, delivery requirements, and technical specification. The first factor, indirect oversight, captures all costs a firm must sustain while accommodating the DoD's regulatory practices. An example are the accounting and timekeeping practices the DoD imposes on firms developing large systems or providing significant engineering effort. The Coopers & Lybrand/TASC study found this factor increased value-added costs by 18 percent [Coopers & Lybrand/TASC, 1994]. However, since this research is examining commodity purchasing only, it is assumed that all indirect oversight costs are included with a firm's price for a commodity.

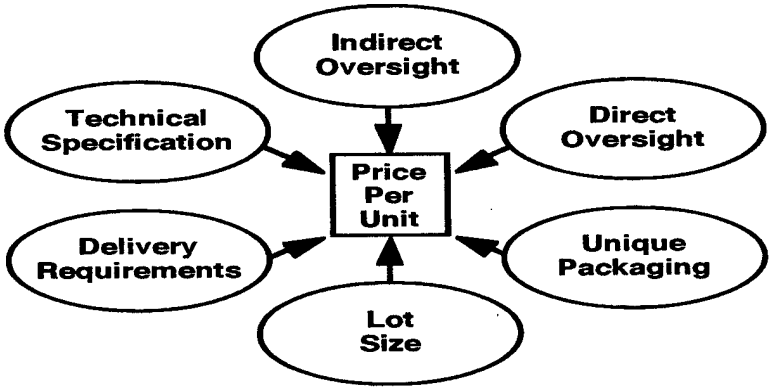

Figure 6: Factors Affecting the Price of a Commodity.

The second factor, direct oversight, is the DoD's labor costs to perform all of their oversight and buying activities while buying a commodity. Once a DoD weapon system is fielded, an item manager is assigned to oversee the management and acquisition of spare parts and subsystems. Each item manager has a team of buyers and contracting officers to purchase spare parts. In some cases, the item manager and contracting officer will employ the services of on-site personnel within a contractor's plant. This analysis will consider how these labor costs affect the DoD's overall costs compared to the commercial sector in the commodity case studies.

The third factor, unique packaging requirements, consists of additional costs industry must sustain in order to accommodate the DoD's packaging requirements. The DoD often imposes unique

packaging requirements, including special barcoding labels, in order to more easily manage and extend the shelf-life of a product. For example, some equipment may need to be deployable to the hot and humid environment of Southeast Asia or hot and dry climate of Southwest Asia without ruination from oxidation or mildew. This factor is considered within the analysis of one sample of commodities.

The fourth factor, lot size, captures the volume of buying by a sector. Very often, differences in price of a good are easily explained when one considers the differences in purchasing power or behavior between the sectors. Many commodities are sold in the commercial and DoD marketplace with various price breaks at certain quantities. This phenomenon is easily seen at any grocery store. The unit price for an item like a roll of toilet paper or paper towels is cheaper if one chooses to buy a six- or twelve-pack rather than a singular roll. The effects of lot size are considered within the analysis of one sample of commodities.

The fifth factor captures unique delivery requirements a sector may impose on a manufacturer. This factor could significantly affect the price of a good. For example, many complex pieces of equipment and associated parts require significant delivery lead times. If an emergency arises and a customer needs the item quickly, the manufacturer may be able to accommodate the customer, but the customer will almost surely have to pay a premium commensurate with the disruption imposed on the manufacturer. Some manufacturers have very stable production runs or operate a particular line seasonally and cannot react quickly and cheaply to sporadic demands within imposing an additional cost. Another facet of this factor are minimum buy policies that manufacturers impose on customers. These policies are really an attempt to help the customer organize it purchases effectively and allow the manufacturer to operate more efficiently. Unique delivery requirements are considered within one sample of commodities.

The sixth factor, technical specification, is perhaps the most maligned factor when past researchers or the media attempted to portray DoD buying practices in a poor light. This factor was discussed earlier in regard to the detailed specifications formally used by the DoD to buy such things as fruitcakes and ashtrays. This factor includes unique quality, reliability, performance, or data

requirements a customer may impose on a manufacturer. This factor is not considered in this analysis because only identical, commercial goods are used as the basis of comparison for the two purchasing sectors.

3.3 Considerations in the Selection of Commodity Purchases

The vast majority of the DoD's purchases are for commodities. The data samples collected for this analysis come from two sources: DoD's buying centers and firms that have sold common products to both markets. The comparisons consist of not only price differences, but also the total dollar value of each purchase along with the relevant factors identified in the previous section. This section examines how the commodities were selected for comparison. The selection of commodities for comparison is a balancing act between data availability, reliability, and comparability. This section closes with a discussion of confidentiality and whether it introduces a bias in the data collection process.

Selection of Commodities: The collection of data on commodity purchasing involved: 1) questioning low-level suppliers and 2) collecting random samples from the Defense Logistics Agency (DLA) and various DoD maintenance and buying centers. The DLA does some bulk purchasing while the logistic centers buy parts and equipment specific to their mission. For example, at the time the engine sample was collected, Kelly Air Force Base, San Antonio, Texas, was the logistic center for engine overhaul for the Air Force and some Navy aircraft, buying many of the engine-related parts used by the DoD.

Three sectors were targeted for data collection: electronics, engine, and commercial-off-the-shelf (COTS) software components.[11] Many goods from the electronics and engine sectors are common to DoD and commercial buyers. The DoD is a minor buyer in the electronics sector and a major buyer in the engine and avionics sector. In the COTS software market, the DoD is a large buyer, but their purchases are dwarfed by the much larger overall commercial market.

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[11] A small subset of the electronics sample consists of avionic parts, primarily various types of hydraulic switches.

Data Availability: Despite the existence of a commodity purchased by both sectors, the data may not be available for comparison. There is no master procurement list detailing the population of commodities purchased by both sectors. One must research the variety of commodities purchased by the DoD, identify the buying activity for a particular sector, and then receive permission to collect a sample of purchases. Government buying activities were contacted and interviews conducted to determine how to identify and arrive at a sample of commodities sold in both sectors.

On the commercial side, collecting purchase information is even more of a challenge because rarely is pricing information readily available. For example, thousands of suppliers provision the DoD in the electronic sector. To get a picture of their pricing behavior in the commercial sector, one must contact the firms individually and solicit their cooperation in providing this information. On the DoD side it is much easier because there is typically one or a few buyers within a particular sector. The relationship is one DoD buyer to many commercial suppliers.

Whether a commodity or group of commodity purchases is available for comparison still depends upon whether the respective organizations are willing to cooperate and the data exists. Not all DoD organizations were willing to cooperate. Similarly, many commercial firms are extremely reluctant to take part in this sort of study. There is a great deal of fear in the DoD procurement community. The fear has at least three sources. First, many firms do not want to run the risk of irritating their DoD customer in any way. Second, two low-level suppliers were raided by the FBI during the Summer of 1995 because of alleged overpricing. The government, by law, is never supposed to pay a price worse than a commercial customer, though it is rarely enforced. Because many factors influence price, this is a gray area many firms prefer to stay away from. Third, many firms treat pricing information like intellectual property. Some even require customers to sign non-disclosure statements regarding what they paid for a good.

Data Reliability: Another challenge is the reliability of the data gathered. This takes on multiple facets: distrust of government personnel, timeliness, or whether the record of a purchase

still exists months after it has transpired. One could argue that government buyers are capable of skewing the data collection process in order to look good to some researcher. This risk can be mitigated by looking first hand at the contracts within a sector as part of the data collection process. All of the data in this analysis was collected in that manner except for the electronics sector. The possibility that multiple buying organizations would fabricate contract files to fool a researcher is remote. Furthermore, some of the purchases were corroborated by evidence from the actual firms. In the case of the electronics sector data, the commodity purchases were provided from a pool of commercial buys for which the depot had complete data.

It is possible the depot personnel selected purchases where the government did well compared to the commercial sector and then claimed the other purchases lack pieces of data. The problem with this rationale is that there really is no way the government personnel could have determined what was a good buy and what was a bad buy. How would they have written a computer program to collect only commercial commodity buys in which the government was the best buyer? Commercial pricing data does not exist in their system and they certainly did not have time to call vendors and add such data in the span of time between my initial contact and visit to their depot. Furthermore, the low-level contracting and programming personnel that provided the data and background discussions, following introductory meetings with the depot's senior management, were stunned that a researcher was even being allowed to pursue such research. They were stunned because they completely expected any such study to portray them as poor buyers. They did not have a specific evidence other than they had been conditioned by the media to believe they were inept buyers of commodities.

The time interval between the time the data was collected from the depot and the commercial organizations were contacted could affect the reliability of the electronics data. This interval was always three to twelve months and not all commercial organizations kept pricing material even that old, so some commodity purchases were omitted. Another side of the problem was the DoD's very own data. Although the depot's personnel claimed the size of the problem as very small, some of the commercial purchases were missing key pieces of data. The depot's programming representative

said this was an attribute of the depot's conversion of historically military items to strictly commercial classification. During 1995, the DESC was systematically reclassifying those parts in its inventory of commodities that could be satisfied by a purely commercial part. The data migration process was not perfect and introduced what is commonly referred to in the Information Technology sector as "dirty data." These are records with either missing or incorrect data.

Data Comparability: Another problem with comparing commercial and DoD prices is what is the fair basis of comparison. Should retail or wholesale prices be used? Where possible, retail and wholesale prices were gathered for a commodity. In absence of such pricing practices, pricing based on lot size was used. Under those circumstances, the smallest salable lot size is assumed to be the retail price. The wholesale price is then assumed to be either the price commercial firms pay when buying in lot sizes equivalent to the DoD or the price commercial firms pay when buying in their typical lot sizes. The analyses of the commodity data will take into consideration the different price bases. Although some results of comparisons of DoD to retail prices are provided, this analysis focuses primarily on DoD performance compared to the average commercial sector organization, where the average commercial sector organization is buying at commercial wholesale prices.

Confidentiality: Most of the DoD organizations and commercial firms taking part in this research are not identified. Furthermore, specific products and prices will also not be identified. Confidentiality is essential for gaining access to procurement information, particularly for a buying activity or manufacturer that understands that their practices and outcomes may be embarrassing to their organization or provide a competitor insight into their proprietary pricing practices. With the power of computers, it is trivial for an auditor to identify a manufacturer or DoD buying activity perceived to be overcharging the DoD or shirking their responsibilities, respectively. DoD agencies and their contracting firms, in general, are extremely sensitive to public disclosure of any information that may embarrass the respective agency. Despite assurances of confidentiality, many firms and, initially, a few DoD organizations were reluctant to participate in this research.

The refusal of some firms and DoD organizations raises the specter of bias. Is it possible that the DoD will appear better in this analysis because the poorly performing organizations refused to participate? Yes, the possibility exists, but experience with the data collected as part of this research points in the opposite direction. First, eventually all of the DoD firms asked to participate ended up participating to some degree, some more reluctantly than others. Second, for the aforementioned question to be true, one would expect that all of the participating buying activities would consider themselves as good organizations outperforming the commercial sector. Although in nearly every case there was enormous pride on the part of the DoD buyers and genuine belief that they were doing their best for the taxpayer, despite any direct contrary evidence bearing on their efforts, they felt sure the commercial sector was doing a better job. The phenomenon is a lot like the child who, after being repeatedly told by his parents and teachers that he is stupid, begins to believe it even though he is faced with a wealth of contrary evidence. The buyers had no specific evidence they were doing poorly, but they had been conditioned by the media to believe the worse.

Third, of the firms that opted for non-participation, the vast majority of the affected dollars from the discarded contracts point to the DoD being the better buyer. For example, approximately $350,000 over seven contracts in the electronics sample was excluded because a broker that sells these particular products as a retailer is prevented legally from providing the price they pay to the manufacturer. The manufacturer explained they were legally bound to their brokers not to provide their prices. One broker finally provided me with a "ballpark" markdown from the list price for the range of products, which was significantly above the price charged the DoD by the manufacturer. Since the broker did not provide the individual markdowns, those purchases were discarded entirely. Collectively, they comprised approximately 10 percent of the total value of the electronics sample and would have enhanced the DoD's purchasing position relative to the commercial sector.

Another important facet of confidentiality is that in some cases it is just not possible to protect an organization from disclosure. For example, this dissertation's focus on the electronic and engine sectors necessitates the participation of the Defense Electronics Supply Center (DESC) and the Air Force's San Antonio Air Logistics Center, respectively. However, specific engines, parts,

personnel, and manufacturers will not be identified except where the substance of a discussion is already a matter of public record.

Treating various facets of the analysis as confidential is a common feature of this genre of research. The jobs and careers of DoD buying and selling personnel could be adversely affected if unfavorable information is brought to the public's or a competitor's attention. Past research produced by Peck and Scherer [1962], the seminal work on defense procurement, Gansler [1982], CSIS [1991], and the Coopers & Lybrand/TASC [1994] study all contained aspects of confidentiality in order for the researchers to secure, analyze, and publish vital information regarding the DoD procurement sector. Even good news or a success story can sometimes bring unintended consequences to a program or its management. Burton provided an incident from 1980 in which the program manager for the Air Force's A-10 ammunition procurement, Colonel Bob Dilger, was allegedly fired within hours of briefing much of the Pentagon's Air Force leadership on how he had introduced competition in his procurement and drove **down** the price of a cannon shell (essentially a commodity) from $83 to $13 [Burton, pp. 106-107].[12]

3.4 Analysis of Commodities

As part of the testing of public sector beliefs about DoD purchasing, the commodity purchases are analyzed for at least three purposes: 1) to determine the relative efficiency of DoD when buying commodities, 2) to identify the parameters affecting the relative efficiency of the DoD, and 3) to determine if the type of commodity influences the relative efficiency of DoD commodity buying.

The first piece of analysis evaluates the relative efficiency of the DoD's commodity buying practices by comparing differences in price using unweighted and weighted price comparisons. Unweighted and weighted price comparisons are conventions of this research. What is occurring is

[12]The A-10 Warthog is the tank killing aircraft that was the big success story of the Gulf War. Colonel Dilger's success was a source of embarrassment. Colonel Dilger was a fighter pilot and not a graduate of any of the Air Force's procurement schools, yet he managed to drive down costs and return unneeded production funding back to the Air Force. In the sometimes perverse world of DoD procurement, the "inability" to use all of one's allocated funding is taken as a sign of poor management rather than efficiency.

that an event, a purchase, has been recorded. Within each sample, this event has a certain frequency of occurrence. The unweighted price comparison assumes that each purchase occurs with the same frequency. Unweighted price comparisons have dominated the literature. The weighted price comparison assumes a different frequency distribution for the purchases, one based on the volume of government buying in total dollars of that item within the entire sample. The price comparison used in this dissertation is:

$$\sum_{i=1}^{n} \frac{\left[P_d^i - P_c^i\right]}{P_c^i} \bullet f(i) \qquad (1)$$

where P_d is the price the DoD paid, P_c is the price the commercial sector pays, n is the number of items in the sample, and f(i) is the frequency with which this item is purchased in the sample. In the case of the unweighted price difference, f(i) remains constant and is equal to 1/n for every item in the sample.

The selected formula for unweighted price difference is the approach typically found in the literature. This approach, however, does not represent price differences consistently between the DoD and commercial buyer. A price difference in favor of the DoD will always be constrained between 0 and -1; however, that same price difference in favor of a commercial buyer will fall between 0 and infinity. For example, consider the situation where the DoD purchases a commodity for $100 and a commercial organization purchases the same item for $150. Using Formula (1), with f(i) remaining a constant 1/n, the resulting unweighted price difference is -.333. If the situation is reversed, with the DoD paying $150 and the commercial organization paying $100, the price difference then becomes .5. Thus, this approach to computing price differences introduces a bias against the DoD. This bias is graphically depicted in three dimensions in Figure 7 by varying the DoD and commercial prices on each axis and plotting the resulting price difference. As the ratio of DoD price to commercial price increases beyond one (left portion of graphic), the resulting price difference rises to approach infinity. The right-side of Figure 7 shows that when the ratio is less than

one, the resulting price difference is constrained to vary between 0 and -1 on % Price Difference axis (Z-axis).

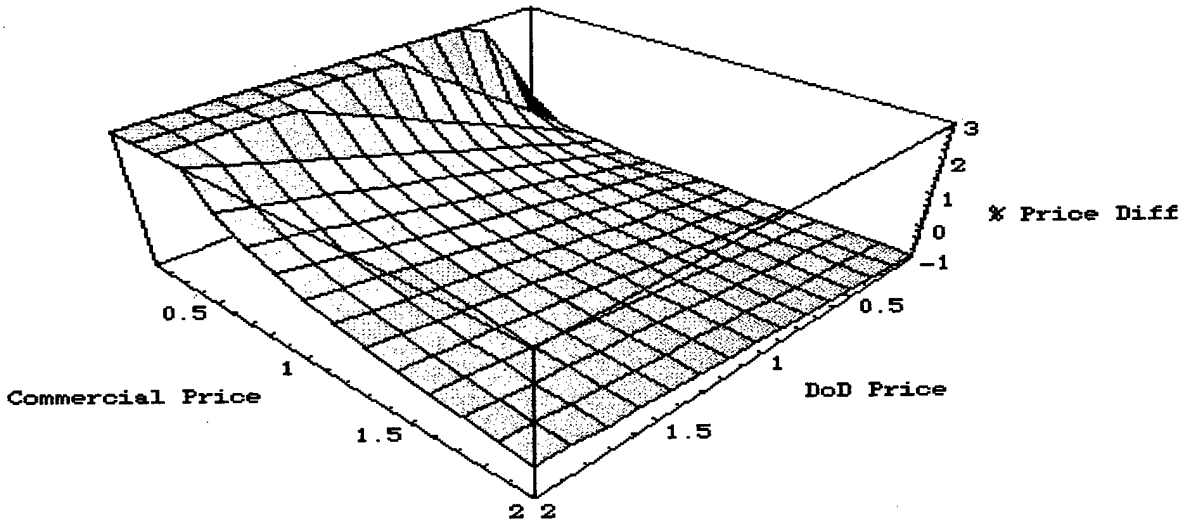


Figure 7: Percent Price Difference From Formula (1) as the DoD and Commercial Price Are Varied.

To highlight how the mean unweighted price difference is computed, a small sample is constructed by drawing one purchase each from Tables 3 and 4, and the electronics, engine, and software commodity samples. The small sample is presented in Table 6. Applying Formula (1) above, where f(i) = 1/n, the mean unweighted price difference is calculated to be 200 percent (average of the % Price Diff column). This implies that the commercial buyer is the better buyer, although the DoD received the better price for three of the five purchases.

Table 6: Small Sample Drawn From Tables 3 and 4, and the Electronics, Engine, and Software Commodity Samples.

ITEM	DoD Price	Wholesale Price	Quantity	% Price Diff
Conduit, one inch	$2.17	$2.20	1000	-0.0136
Aircraft Video Tape Recorder	$7,000.00	$2,500.00	100	1.8000
Diode	$9.33	$0.90	4	9.3667
Turbine Blade, 3rd Stage	$151.40	$371.40	20000	-0.5924
RDBMS-runtime client	$371.45	$837.00	5500	-0.5562

The second price analysis, using weighted price differences, is the same as (1), but the frequency of the *ith* item being purchased, f(i), varies based upon the total dollar value of DoD purchases of that item as a percentage of total DoD purchasing within the entire sample. The total dollar value is determined by multiplying the DoD price by the DoD purchase quantity. Thus, f(i) for the weighted price differences becomes:

$$f(i) = \frac{V_d^i P_d^i}{\sum_{j=1}^{n} V_d^j P_d^j} \qquad (2)$$

where V_d is the number of items bought by the DoD. The other variables are identical to those found in formula (1). This approach to weighting the price differences is chosen because it puts the DoD at the greatest disadvantage in the analysis. If either the total commercial value of the purchases or the combination of DoD and commercial purchases is chosen as the weighting scheme, then purchases where the DoD receives a better price will receive more emphasis and those where the DoD receives a poorer price will receive less emphasis. Using the total dollar value of the DoD's purchases as the weighting mechanism maximizes the emphasis on those purchases where the DoD is a poor buyer and minimizes the effect when the DoD is the better buyer. Thus, it is more difficult for the DoD to emerge as the better buyer using this scheme.

A new concern may be that weighting purchases introduces a bias into the analysis. This might be true if 1) all purchases occurred with equal frequency and 2) the DoD employed uniform buying practices regardless of the cost and nature of the item being purchased. Neither of these conditions are true. First, Chapter One presented evidence that more than 90 percent of DoD contracts are valued at less than $25K. Not every contract is the same and neither are individual items purchased in the same total dollar volumes. Second, the DoD's purchasing processes are such that different practices are employed for higher cost items. The DoD does not treat important, expensive items the same as the purchase of a 10-cent O-ring. Third, this research seeks to evaluate the DoD's aggregate buying performance. Trivial, low-dollar purchases, though fair game for the

Evening News, provide little insight into how well the DoD manages the vast majority of its procurement dollars. Lastly, weighting purchases is a new theoretical concept this research seeks to investigate rather than a potential bias.

To illustrate how the weighted price difference affects an analysis, the synthesized sample from Table 6 is re-examined using synthesized quantities for the first two items and the actual DoD purchase quantities for the last three items: 1000, 100, 4, 20000, and 5500, respectively. The DoD's purchase quantities are used to not only provide an appropriate, consistent basis of comparison, but the above discussion shows that this weighting mechanism places the DoD at a disadvantage in the analysis. Using these quantities, the total dollar value of each purchase in the small sample may be computed. These totals are presented in Columns IV and V of Table 7.

The weighted price analysis uses Formula (1); however, f(i) for an individual purchase is now determined by taking the total dollar value of that purchase and dividing it by the DoD's total dollar value of the sample (see Column II of Table 7). One may arrive at the weighted price difference by multiplying Columns II and III and summing the resulting products. The weighted price difference is now -28.9 percent. This means that the DoD is the better buyer in this small example. This finding is certainly more consistent with the totals found in Table 7, where the DoD spends approximately $6.5 million less for the same five purchases. In terms of total cost, the commercial cost is approximately 113 percent higher than the DoD's total cost.

Table 7: Total Dollar Value of Each Purchase in Table 6's Small Sample.

I	II	III	IV	V
ITEM	f(i)	% Price Diff	DoD Total	Wholesale Total
Conduit, one inch	.0003759	-0.0136	$2,170.00	$2,200.00
Aircraft Video Tape Recorder	.1212503	1.8000	$700,000.00	$250,000.00
Diode	.0000065	9.3667	$37.32	$3.60
Turbine Blade, 3rd Stage	.5244941	-0.5924	$3,028,000.00	$7,427,980.00
RDBMS-runtime client	.3538733	-0.5562	$2,042,975.00	$4,603,500.00
			$5,773,182.32	$12,283,683.60

A separate discussion on the determination of the sample variance in the weighted case is warranted. The sample variance is important for determining whether the calculated mean weighted

price difference is statistically significant from zero. If one multiplies the squared error for each event by the frequency of occurrence, f(i), and sums each product, then one arrives at a biased estimator of the population variance. To eliminate the bias, the estimator must be multiplied by n/n-1. Thus, the unbiased estimator of the population variance is:

$$\hat{S}^2 = \left(\sum_{i=1}^{n} \left(P_d^i - \overline{P} \right)^2 \bullet f(i) \right) \bullet \frac{n}{n-1} \qquad (3)$$

The third type of analysis aggregates all commercial and DoD purchases to arrive at the dollar totals, computes the ratio of total commercial to DoD buying cost, and then subtracts one to arrive at the relative efficiency. This method compares the DoD cost to purchase all of the goods in a sample to the commercial cost to purchase the same goods. The mathematical representation is:

$$\frac{\sum_{i=1}^{n} \left[P_d^i - P_c^i \right] V_d^i}{\sum_{j=1}^{n} V_d^j P_d^j} \qquad (4)$$

As an illustration, the data provided in Table 6 was analyzed using this method of price analysis, Total Cost Difference. That result showed that the DoD was the better buyer by 113 percent. The results of all three analyses of the Table 6 data are presented in Table 8, where Column I used formula (1), Column II used formula (1) and formula (2) for f(i), and Column III used formula (4).

Table 8: Results of Applying The Three Price Difference Formulas to Data in Table 6.

	I	II	III
	Unweighted Price Difference	Weighted Price Difference	Total Cost Difference
Table 6 Data	2.001	-0.289	-1.128

A weakness of past research has been the lack of representativeness of the data forming the sample. This dissertation is addressing one facet of the representativeness issue by weighting the purchases within each sample based upon the total dollar value of DoD's purchases. The second major piece of analysis uses hypothesis tests (tests of means) and regression analysis to determine how lot size, unique packaging, and minimum buy/delivery requirements affect the prices paid by the DoD within the electronic sample. These factors were only considered in the analysis of the electronic sample.

3.5 Case Studies

Case studies are employed to try to understand factors that are not directly obvious when simply comparing commodity purchase outcomes between the DoD and commercial sectors. The case studies will consider the DoD's direct buying costs for some of the commodity samples. These case studies are presented to examine facets of DoD purchasing that remain hidden when performing only statistical analyses of the DoD's purchasing performance. These studies are particularly important because the findings from the Coopers & Lybrand/TASC study [1994] continue to be held in high esteem by the DoD's leadership. For example, the Defense Science Board's Summer Study on Achieving an Innovative Support Structure for 21st Century Military Superiority calls for "keeping the heat on Acquisition Reform," stating that savings of $10B a year are possible [Gansler and England, p. 48, 1997]. The study cites no specific evidence for this claim of possible savings other than the Coopers & Lybrand/TASC study, and then misquotes the study by claiming "the DoD adds 20% or more to equipment purchase costs." The study actually claims only an 18 percent cost impact from onerous DoD oversight practices and regulations [Coopers & Lybrand/TASC, 1994]. The case studies present more evidence of the DoD's overall buying performance.

4.0 Electronic Sector Findings

This chapter examines the findings from the electronic sector. This sample includes a small number of avionics parts (n = 10). They are combined because the components as well as their collection was similar and some of the items categorized as electronic components in this sample would be categorized as avionics by some in the DoD.[13]

The DoD portion of the electronic commodity sample was collected from the Defense Logistic Agency's (DLA) Defense Electronics Supply Center (DESC). At the time, DESC was in the process of categorizing, where appropriate, items they purchase as commercial commodities. The alternative is non-standard items purchased using military specifications from approved vendors. In the Summer of 1995, approximately 12,000 of the more than 100,000 items they purchase were identified as being strictly commercial items. The DESC supported this research by collecting all of the purchases for those items within approximately 18 months. This sample consisted of approximately 2500 purchases by the DoD of commercial items. The sample contained purchase quantities, prices, stock numbers, and company names and addresses. For this dissertation, a sample was then drawn in a pseudo-random[14] fashion from the 2500 purchases.[15]

The commercial portion of the pricing data was gathered by directly contacting the sales or contracting departments of the companies. Overall, communication was attempted with 111 companies involving 384 electronic commodity purchases. Five outcomes were realized from each attempted contact: 1) company took part, 2) company refused, 3) company could not be located, 4) company out of business, or 5) the company does not sell to the commercial sector. There were 15 companies that either refused to participate overtly or never returned phone calls or fax requests for pricing information. Their contracts were worth approximately $656,000 to the DoD over 35 purchases. For categories (3) through (5), there were 20 companies involved with contracts worth

[13] The Air Force, for example, would consider any electronic component flying in an aircraft to be an avionics part.
[14] After conversion, the 2500 purchases were contained in a large file. Large blocks of purchases were cut and pasted into a new file that comprised the electronic sample. After pasting a block into the sample file, the large file was scrolled for a few seconds and then another block selected, cut, and pasted into the sample file. This was done several times to form the electronic sample.
[15] The 2500 purchases should not be construed to be the population of commercial buys by DESC. Other purchases were detected, but pieces of data were missing. Those purchases were excluded from the sample collected by DESC.

approximately $360,000. There were 76 companies that participated and their contracts were worth approximately $2.7 million.

This chapter will first look at the results of the unweighted price difference analysis. The next section will present the weighted results and contrast how they differ from the unweighted price differences. Included in that analysis will be the results of the total cost difference analysis. The data are then stratified based on the criteria identified in the research approach to determine what if any ancillary factors affect pricing in this sector. These findings are compared with the results of the regression analysis. A sensitivity analysis is then performed to determine the robustness and dependence of the findings on this sample of data. This chapter closes with a discussion of how the DoD performed against the average commercial sector organization.

4.1 Results of Unweighted Price Difference Analysis of Electronic Sector Data

The electronic parts sample is comprised of 329 separate part purchases in varying quantities by the DoD. The prices in this sample have been compared to prices commercial firms pay. Comparing DoD and commercial wholesale prices using formula (1), unweighted price difference analysis, reveals the DoD pays 70.2 percent more on average than commercial wholesale prices. A t-test was performed to determine whether this mean was significantly different from zero. The finding was statistically significant, with $p < .001$.[16]

The histogram of unweighted price differences is presented in Figure 8. A negative price difference indicates the DoD received a better price and a positive price difference indicates the commercial sector received a better price. The height of each bar indicates the number of purchases found within the respective unweighted price difference range. This histogram reveals that most of the purchases comprising the electronic sample fell on the positive unweighted price difference side

[16] Throughout the remaining analysis chapters, unless stated differently, if a claim of statistical significance is made, one can assume that a t-test was performed to determine whether the respective mean is significantly different from zero.

of the histogram, indicating that on average the commercial wholesale customer received a better price.

The DoD's purchases were then analyzed against the commercial retail prices for each part. As one would expect, the price difference diminishes as commercial retail prices are typically higher than commercial wholesale prices. The DoD still paid 51.9 percent more than commercial retail prices using unweighted price analysis ($p < .001$).

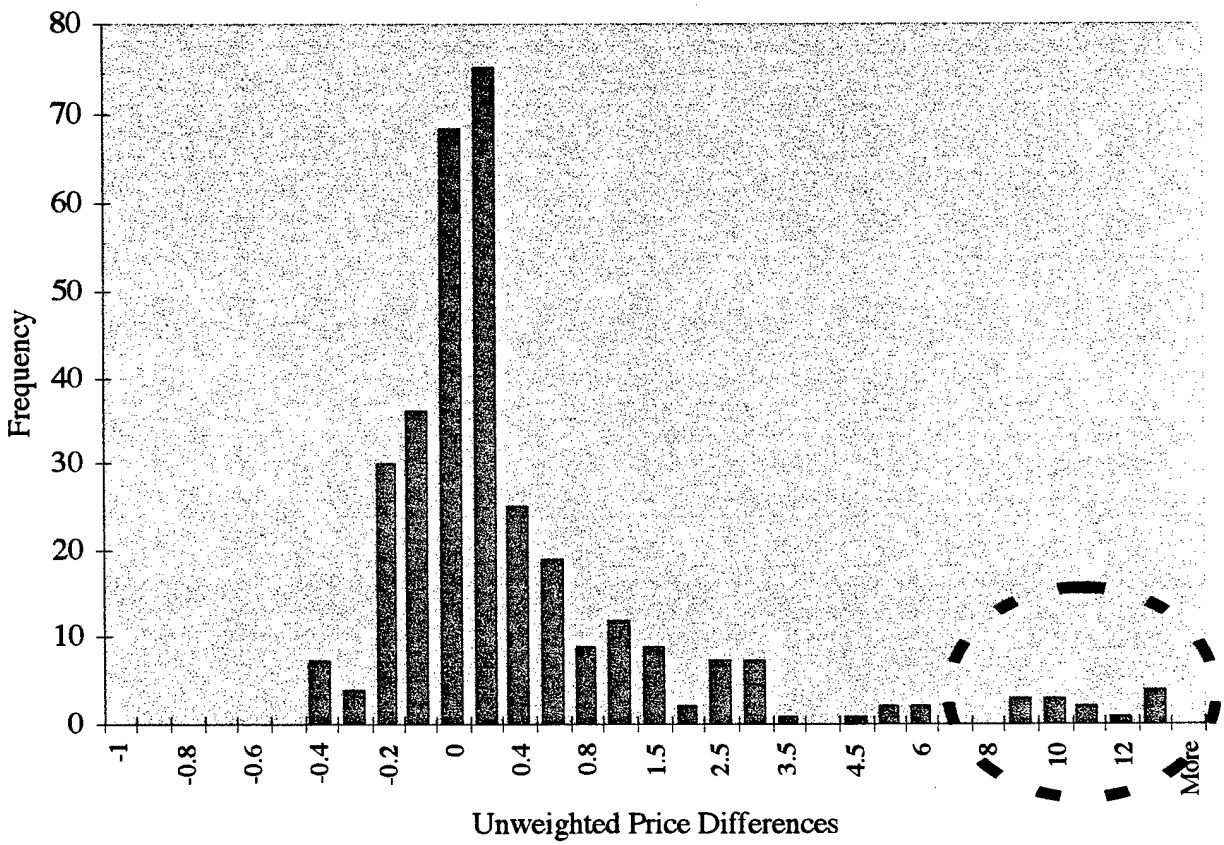


Figure 8: Histogram of Unweighted Electronic Commodity Price Differences.

Several significant outliers are highlighted in Figure 8 using a dashed ellipse. These are cases where the DoD paid vastly more in terms of price than the commercial sector. For example, the sample contains several 25- to 50-cent capacitors or diodes purchased for several dollars. Any one of these outliers would make good candidates for media exploitation. More importantly, however, each of these outliers were purchased in extremely small quantities. The

effect of purchase quantity and price are now evaluated by weighting each purchase based on its total dollar value in the overall sample.

4.2 Results of Weighted Price Difference Analysis of Electronic Sector Data

Weighting the price differences based on the total dollar value of each purchase changes the findings significantly. Once the total dollar value of DoD buying is considered using formula (2) for the frequency of purchase occurrence, the DoD pays 5.9 percent less than commercial wholesale prices ($p < .02$). Against commercial retail prices the results are consistent; the DoD pays 22.6 percent less ($p < .001$).

The histogram of the weighted price differences is presented in Figure 9. Each weighted price difference in the histogram is nothing more than the price difference times each purchase's dollar value divided by the total dollar value of the sample. The histogram reveals a shift to the left in the distribution of price differences when compared to the unweighted price difference histogram. Although the sign of each price difference remains the same, the bulk of the positive price differences shifts towards the center or no price difference. Interestingly, the outliers disappear because they consisted of low dollar value and small quantity DoD purchases. The mass of the histogram shifts to the left because the majority of high dollar value purchases are in the favor of the DoD; i.e., the DoD performs better on average buying high dollar value items when compared to the average commercial organization. The histogram graphically captures what the weighted price difference analysis revealed above.

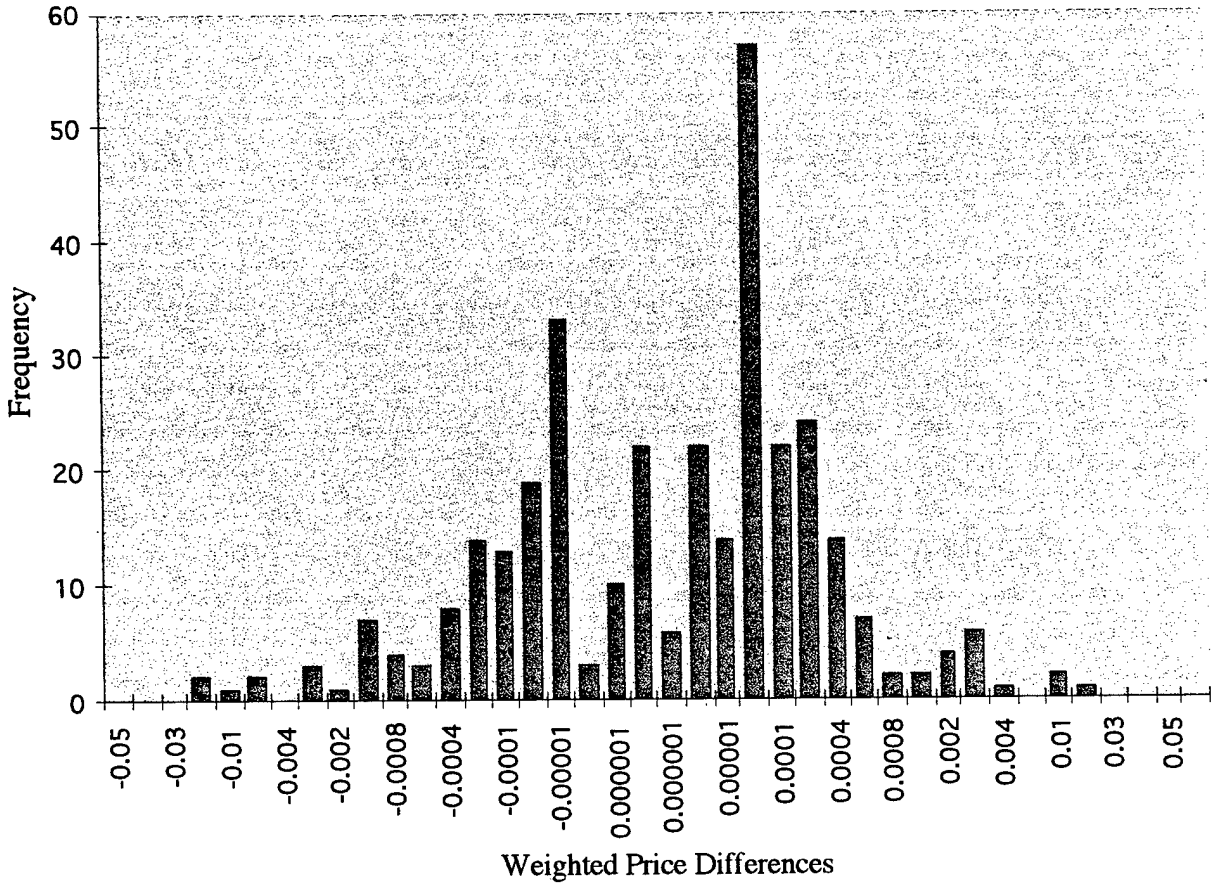


Figure 9: Histogram of Weighted Price Differences for Electronic Commodities.

Another perspective is provided by multiplying prices and lot sizes for each commodity and then aggregating the products. In the aggregate, using formula (4) from Chapter 3, the DoD pays 14.4 and 49.9 percent less than the commercial wholesale and retail prices, respectively. The DoD paid $2.675 million for the parts in the sample while the commercial wholesale and retail cost of the identical parts would have been $3.06 and $4.01 million, respectively. The findings from the electronic commodity sector are summarized in Table 9, where negative price differences reflect DoD buying performance that is better than the average commercial firm. These findings are contrary to conventional wisdom and much of the data found in the literature.

Table 9: Summary Results in Percentages of Applying The Three Price Difference Formulas to Electronic Commodities Data.

	Unweighted Price Difference	Weighted Price Difference	Total Cost Difference
Wholesale Prices	70.2*	-5.9**	-14.4
Retail Prices	51.9*	-22.6*	-49.9

*p < .001 **p < .02

4.3 Results of Stratifying Electronic Sector Data

The first part of this section separates the avionics from electronic data to determine whether differences exist between the unweighted and weighted price differences. The second part examines how the ancillary factors outlined in Chapter 3 may affect the price of a component: special packaging requirements, minimum buy quotas, and lot size ratios.

The unweighted and weighted price difference analyses reveal that the DoD paid 145 and 97.5 percent more than commercial wholesale prices for avionics parts, respectively ($p < .01$). Analysis of the electronic sample reveals findings similar to the last sections: DoD paid 67 percent more than the commercial sector according to the unweighted analysis, but once the prices were weighted, the DoD was found to have paid 8.3 less than the average commercial sector organization in terms of wholesale prices ($p < .001$). Table 10 presents the results of separating the Avionic and Electronic data.

A test of means was then used to compare the unweighted and weighted price differences for the Avionic and Electronics sub-samples to determine whether they are significantly different. In both cases it was found that the unweighted and weighted price difference for the Avionic and Electronic sub-samples are significantly different, with $p < .05$ and $p < .005$ for the unweighted and weighted price differences, respectively (Z-statistic for test of means provided in Z column in Table 10). However, one must use caution with these findings since the Avionic sample size is quite small.

These findings indicate that differences exist between the purchase of avionic and electronic components. Closer examination of the avionic purchases reveals that the purchase quantities were significantly less than those typical of the commercial sector. Across the sample of avionic parts, the average lot size ratio was 12.2, indicating that the commercial sector buys 12.2 times the number on average than does the DoD in a typical purchase. The electronic sub-sample, however, has an average lot size ratio of 2.4. Since the DoD is not purchasing the avionic commodities in efficient quantities, one would expect the price paid by the DoD to be greater. Furthermore, of the 10 purchases comprising the avionic sample, only 4 were significantly above the $2500 threshold requiring human participation in the purchase. One should not expect the DoD to receive a good price for the six small dollar value avionic purchases. The poor avionic part purchasing performance by the DoD relative to the commercial sector and the electronic sample is not surprising once the ancillary factors are examined.

Table 10: Comparison of Electronic and Avionic Sector Commodities Using DoD and Commercial Wholesale Price Comparisons.

Avionic			Electronic			Z	
Unweighted	n	Weighted	Unweighted	n	Weighted	Unweighted	Weighted
145.0*	10	97.5**	67.8*	319	-8.3*	2.1	3.0

*p < .001 **p < .01

The Electronic and Avionic sector data were then recombined to determine whether special packaging requirements, minimum buy policies, and lot size ratios between the commercial and DoD sectors have any influence on price. Tests of means were employed to determine whether the differences by factor are statistically significant. To evaluate each factor, the sample was stratified according to whether a purchase occurred with or without the respective factor. For example, to evaluate special packaging requirements, the price differences for purchases with special packaging requirements were compared to the price differences for the sub-sample of purchases without special packaging requirements.

Special Packaging: In terms of special packaging requirements, it can be seen in Figure 10a that when the DoD imposes this requirement on a commercial vendor, the DoD typically pays the same as the average commercial sector organization in terms of weighted price analysis. Table 10a shows that the DoD pays 2.5 percent more than the average commercial sector organization "With" special packaging requirements ("Weighted" Column within the "With" Block of Figure 10a) and 7.5 percent less than the average commercial organization "Without" special packaging requirements ("Weighted" Column within the "Without" Block of Figure 10a). A test of means reveals these findings are not statistically different ("Weighted" Column Z-statistic in "Z" Block is 1.4).

A minor finding is the increase in DoD buying performance using weighted price differences once the special packaging purchases are removed from the sample. In Section 4.2 it was shown that the DoD buys 5.9 percent (see Table 9 Weighted Price Difference for Wholesale Prices) more effectively than the average commercial sector organization; however, once the data is stratified to eliminate those purchases with special packaging requirements, the DoD's buying performance increases to 7.5 percent more effective than the commercial sector ("Weighted" Column within the "Without" Block of Figure 10a). The difference, however, is not statistically significant. Overall, the imposition of special packaging requirements does not appear to significantly affect the DoD's buying performance.

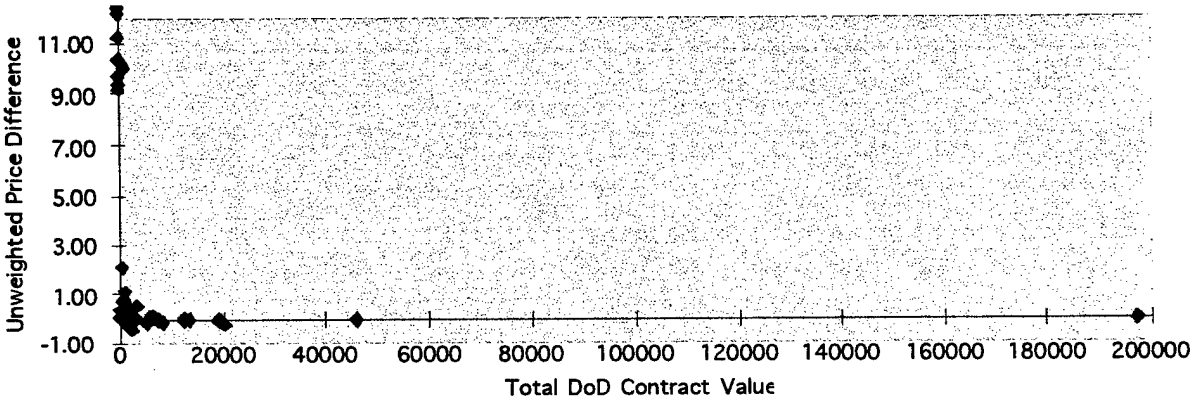
Plots of the stratification of the electronic sample by the special packaging criterion are provided in Figure 10, parts b and c, where the total DoD contract value of each purchase is on the x-axis and the associated unweighted price difference may be found along the y-axis. The plots indicate that when special packaging is required, the vast majority of the data points are found in the area with a positive price difference, indicating the commercial sector buyer outperformed the DoD. The balance of data points, particularly for high dollar value purchases, shifts in favor of the DoD when no special packaging requirements are imposed on the vendor, as seen in Figure 10c.

a. Stratification of Electronic Sector Commodities by Special Packaging Requirements.

	With			Without			Z	
	Unweighted	n	Weighted	Unweighted	n	Weighted	Unweighted	Weighted
Packaging	167.6*	69	2.5	44.3*	260	-7.5*	2.6	1.4

*$p < .001$

b. Plot of Data With Special Packaging Requirements



c. Plot of Data Without Special Packaging Requirements

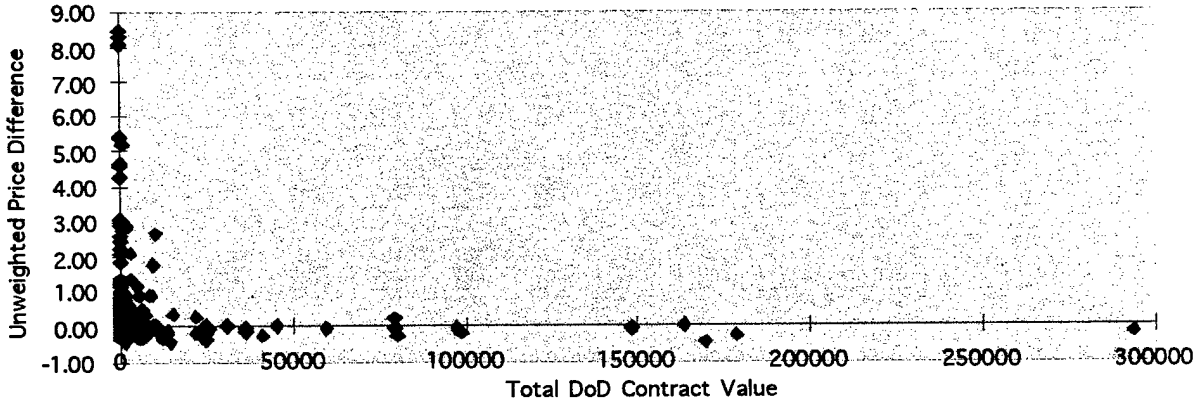


Figure 10: Summary Results of Stratifying Electronic Data According to Special Packaging Requirements. Plots of Unweighted Price Differences Versus Total DoD Contract Value For Special Packaging Requirements.

Minimum Buy: The minimum buy factor reflects whether or not the DoD met the minimum buy criteria imposed by a commercial vendor. Often a vendor requires that an order be of at least a certain dollar value and/or quantity. In 17 cases contained in the overall Electronics sample, the DoD failed to meet the minimum buy criterion of a vendor. In those cases, the DoD paid 95.9 and 78.9 percent more than the commercial sector in terms of unweighted and weighted price analysis, respectively. When the DoD meets the minimum buy criteria of the vendors, the story is different, with the DoD paying 7 percent less than the average commercial sector organization in terms of weighted price difference analysis. More importantly, the findings across this stratification are significant when using weighted price differences. From Figure 11a, it can be seen that the stratification that met the minimum buy criteria ("Weighted" Column of "Without" Block) is significantly different from the stratification that did not meet the minimum buy criteria ("Weighted" Column of "With" Block). A test of means revealed the samples are significantly different (Z statistic equals 4.1). This is an opportunity for the DoD to save more than 80 percent in terms of weighted price analysis by more judiciously buying such that they meet a vendor's minimum buy criteria.

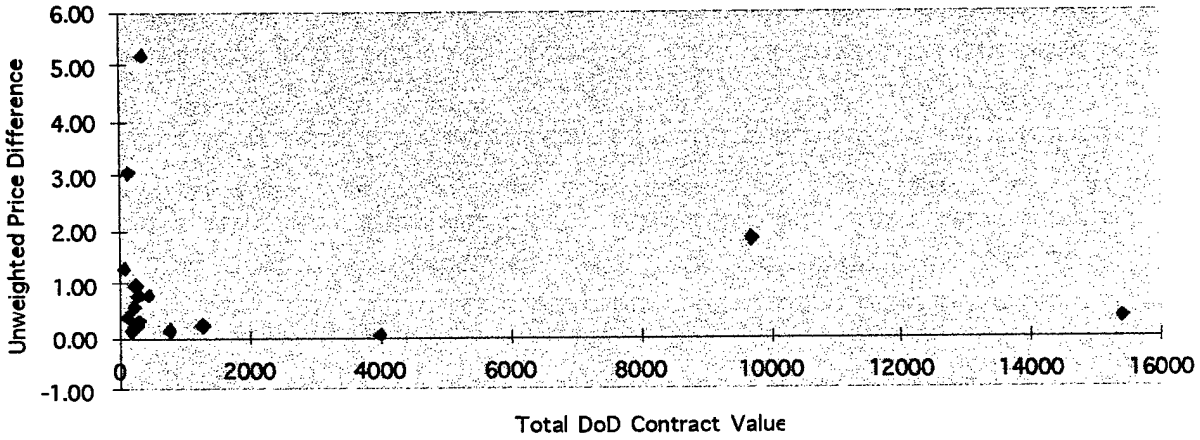
Plots of the stratification by the minimum buy criterion can be seen in Figure 11, parts b and c. Plot b reveals that the DoD paid more than the average commercial firm for every purchase in which they failed to meet the vendor's minimum buy criteria (data points are in the positive unweighted price difference range). This is a finding one should expect. When any organization buys in non-economical quantities, they can expect to pay a premium. The DoD is no different. An examination of plot c finds all of the purchases in which the DoD outperformed the average commercial sector firm. The lesson here for the DoD is to purchase in economically efficient quantities whenever possible.

a. Stratification of Electronic Sector Commodities by Minimum Buy Requirements.

	With			Without			Z	
	Unweighted	n	Weighted	Unweighted	n	Weighted	Unweighted	Weighted
Minimum	95.9**	17	78.9*	68.7*	312	-7.0**	0.8	4.1

*$p < .001$ **$p < .005$

b. Plot of Data That Did Not Meet Vendor's Minimum Buy Requirements



c. Plot of Data That Did Meet Vendor's Minimum Buy Requirements

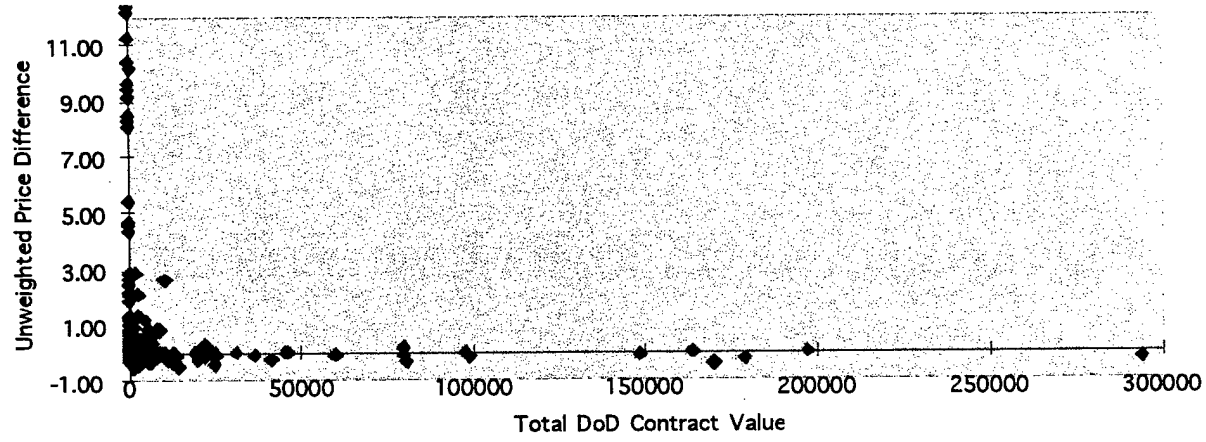


Figure 11: Summary Results of Stratifying Electronic Data According to Minimum Buy Requirements. Plots of Unweighted Price Differences Versus Total DoD Contract Value For Minimum Buy Requirements.

Lot Size Ratios: The lot size ratio (LSR) is the typical commercial sector purchase volume divided by the DoD's purchase volume for an item. This variable is intended to capture whether buying in larger lot sizes matters in the price received from a manufacturer. Three sets of analyses are provided: Lot Size Ratio > 1, Lot Size Ratio = 1, and Lot Size Ratio < 1. When the lot size ratios are greater than one, that is a purchase where the commercial sector buys in larger quantities than the DoD. When the lot size ratios are less than one, the DoD is purchasing in larger quantities than the typical commercial sector firm.

The interesting results from these analyses can be found in the extreme cases, where LSR is greater than or less than 1. Using the weighted price difference analysis for LSR > 1, it is found the DoD pays 27.5 percent more than the average commercial sector firm; however, for LSR < 1, the DoD pays 14.6 percent less than the average commercial sector organization (see Table 11). A test of means reveals these findings are significantly different, with $p < .001$ (z statistic equals 4.2). This is a finding one would expect. Those commercial sector firms buying in larger quantities than the DoD (LSR > 1) outperform the DoD on average in terms of both unweighted and weighted price analysis ($p < .001$). Similarly, when the circumstances are reversed and the DoD is buying in larger quantities than the commercial sector (LSR < 1), the DoD pays 14.6 percent less than the average commercial sector firm using weighted price analysis. However, this finding is not significantly different from the weighted price difference of -8.6 percent when LSR = 1. A test of means between the weighted price differences when LSR = 1 and LSR > 1 was statistically significant, with $p < .001$ (z statistic equals 5.1). These findings show that the DoD receives a better price when purchasing in economically efficient quantities.

Plots of the stratification of the electronic sample by lot size ratio are provided in Figure 12, plots a, b, and c. Plot a presents the LSR > 1 data, revealing nearly all of the high dollar value purchases in which the commercial sector outperformed the DoD. When LSR = 0, plot b, nearly all of the purchases in either the DoD's or commercial sector's favor are of low dollar value, while the more expensive purchases lie atop the x-axis, indicating the DoD and average commercial sector firm performed nearly the same. As one would expect, when the DoD is buying in larger

quantities, plot c, one finds the vast majority of the DoD's purchases in which they outperformed the average commercial sector organization.

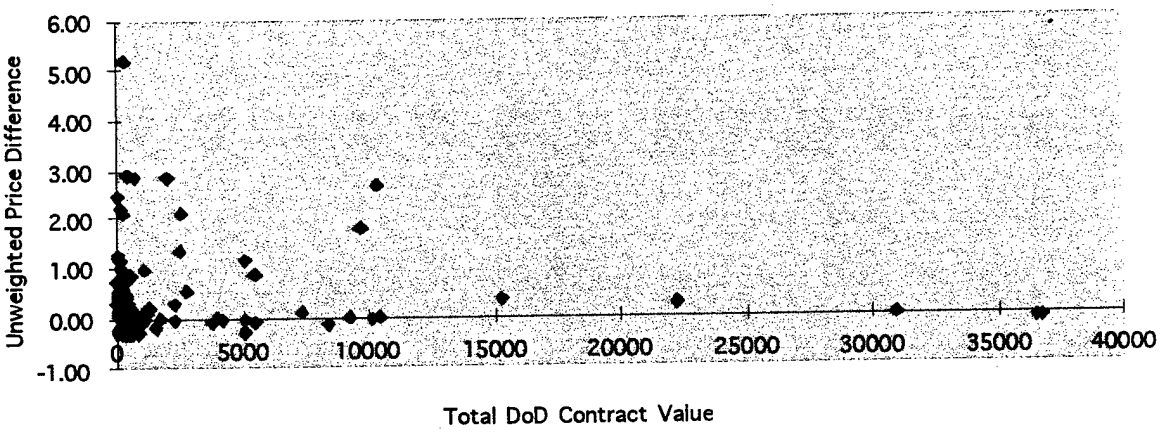
Table 11: Stratification of Electronic Sector Commodities Using Factors Believed to Affect Price of Commodity

	Unweighted	n	Weighted
LSR > 1	43.6*	112	27.5*
LSR = 1	99.5*	174	-8.6*
LSR < 1	20.7	43	-14.6**

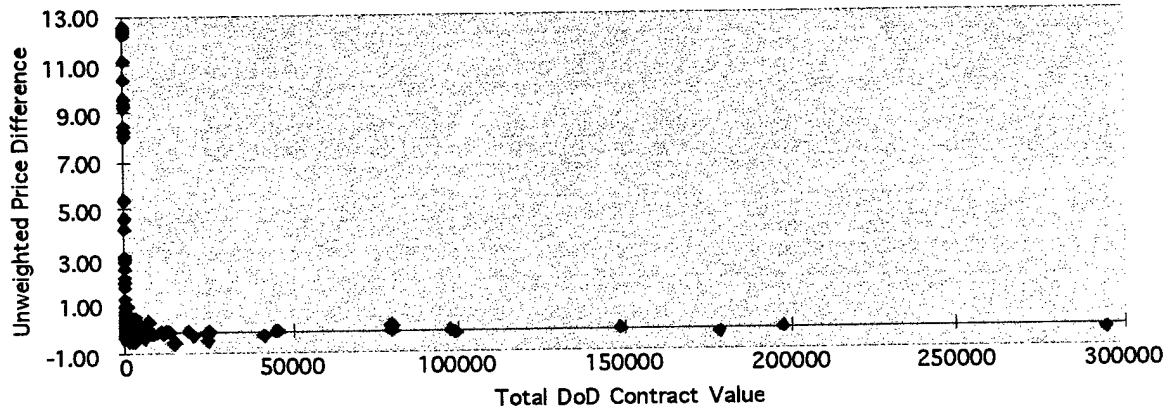
*p < .001 **p < .05

This section presents evidence that certain factors, minimum buy policies and lot size ratios, influence the price a customer receives from a manufacturer. Special packaging requirements was significant in terms of unweighted price differences, but its importance waned once the price differences were weighted. The challenge for the DoD is to take these lessons and apply them judiciously. The small dollar purchases may be hiding repeat purchases of the same item that could be bought more effectively in larger quantities. For example, one vendor contacted as part of this research told how they ship one 10-cent O-ring to the DoD every couple of months; however, the DoD pays $30 for that O-ring since the manufacturer has a minimum buy policy of $30. Another vendor told how they are one of a small number of suppliers in the world for certain airborne hydraulic devices, yet the DoD continually breaks up their buys in order to, hopefully, spread the potential revenue across the few native suppliers. Ironically, these actual manufacturers often do not win the contract awards directly from the DoD. Part brokers, typically minority-owned firms that manufacture nothing, often win the sales because the DoD is trying to accomplish another social goal, promotion of minority-owned businesses. In this case, the DoD ends up paying more for the parts for two reasons: 1) pass through cost to the parts broker and 2) overhead associated with purchasing inefficient lot sizes from several manufacturers when one or two would provide society and, ultimately, the DoD the greatest benefits.

a. Lot Size Ratio > 1 (Commercial customer buys in larger quantities)



b. Lot Size Ratio = 1



c. Lot Size Ratio < 1 (DoD customer buys in larger quantities)

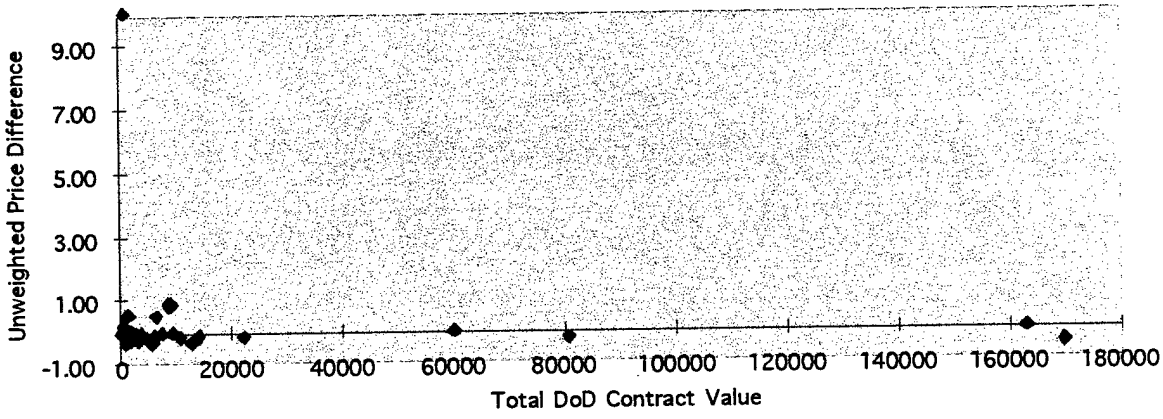


Figure 12: Plots of Unweighted Price Differences Versus Total DoD Contract Value For Various Lot Size Ratios.

4.4 Regression Analysis of Electronic Sector Data

The regression findings provide important insights on the DoD's buying performance relative to the commercial sector that were not seen with simple stratifications of the data found in the previous section. Regression analysis was performed on the unweighted and weighted price differences of the electronic sector data. Some of the findings are complementary to the tests of means from the previous section. For the regression analyses, the dependent variable is price difference, DIFF. For the unweighted regression, the price differences were computed using aforementioned formula (1) with f(i) held constant. The weighted regression used transformed dependent and independent variables, where the transformation consisted of weighting the data based on the volume of DoD buying of each purchase as a percentage of the total DoD cost for the entire electronic sample. The independent variables are dummy variables used to determine how they affect the price: packaging, minimum buy, lot size ratio greater than one, and lot size ratio less than one.

The lot size ratio (LSR) is the typical commercial sector purchase volume divided by the DoD's purchase volume for an item. A ratio greater than 1 indicates the commercial sector buys the respective item in larger numbers. Two additional dummy variables are used to explore whether the DoD's pricing is inflated to cover the unique packaging requirements sometimes required by the DoD and when the DoD's buying is below the minimum order requirements of the respective firm, forcing the DoD to pay a penalty in price. The regression model following from this discussion and Figure 6 in the previous chapter is:

$$DIFF = a + b_1 PACK + b_2 MIN + b_3 LSR>1 + b_4 LSR<1 + u \qquad (5)$$

Unweighted Results: The Coefficient of Multiple Determination or R^2 for the model reveals the independent variables account for 7 percent of the variation in unweighted price

differences in the sample. The adjusted R^2 was found to be 5.9 percent and the F statistic equaled 6.1.

The regression findings presented in Table 12 show that the DoD typically pays approximately 65 percent more than the average commercial sector firm for items that meet a firm's minimum buy and special packaging requirements and possess a lot size ratio equal to one. This finding is from the intercept, which is statistically significant. This finding is also consistent with the unweighted stratifications from the previous section (examine "Unweighted" columns in "Without" Blocks). The coefficient for unique packaging is also statistically significant and drives up the price paid by the DoD by an additional 116 percent. This, too, is consistent with the previous section's finding (see Table 10a, "Unweighted" column of the "With" block, 167.6 percent). The coefficient for minimum buy criterion indicates that it causes the DoD to pay 67 percent more on average; however, the finding is not statistically significant.

Table 12: Regression Analysis Results of Unweighted Price Differences for Electronic Sector Data

	Coefficients	Standard Error	t Stat	P-value
Intercept	0.6509	0.1794	3.63	0.00033
Packaging	1.1570	0.2897	3.99	0.00008
Minimum Buy	0.6734	0.5374	1.25	0.21111
LSR > 1	-0.4434	0.2625	-1.69	0.09216
LSR < 1	-0.5788	0.3589	-1.61	0.10783

The regression results for the Lot Size Ratios are consistent with the previous section's findings, though neither variable is significant. When the Lot Size Ratio is greater than 1 (LSR > 1)—DoD buying in smaller quantities—the coefficient is -44 percent. Assuming the other variables are zero, the DoD is paying 21 percent more than the average commercial sector firm. The stratification results from the previous section indicates the DoD pays 43.6 percent more; however, that finding is influenced by the presence of data points in which special packaging or minimum buy policies were violated. Their presence increases the stratification finding for LSR > 1.

A similar finding is found when the Lot Size Ratio is less than 1 (LSR < 1). Under this circumstance, assuming the other variables are zero, the DoD pays approximately seven percent more than the average commercial sector organization. The stratification results from Table 11 in the previous section indicates the DoD pays 20.7 percent more, but that stratification includes some data points with special packaging requirements or that failed to meet minimum buy criteria. Those data points cause the unweighted price difference to increase; thus, revealing a difference in the quality of the finding. The regression results more accurately reflect the influence of each factor on the price paid by the DoD.

Weighted Results: The regression performed on the transformed data produced stronger results. The Coefficient of Multiple Determination or R^2 for the model reveals the independent variables account for 24 percent of the variation in weighted price differences in the sample. The adjusted R^2 was found to be 23 percent and the F statistic equaled 25.5.

From the regression results in Table 13, neither the intercept or special packaging requirements turned out to be significant. This would indicate that once considerations are made for the volume of a buying in terms of DoD dollars expended, whether the DoD imposes special packaging requirements is not serious cost consideration. The savings from volume buying more than offset any cost additions that may accrue from imposing special packaging requirements. This finding is consistent with the stratification results of the previous section.

Table 13: Regression Analysis Results of Weighted Price Differences and Transformed Independent Variables for Electronic Sector Data

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.0001	0.0001	-0.55	0.58117
Packaging	0.0010	0.0281	0.04	0.97208
Minimum Buy	0.6793	0.3189	2.13	0.03389
LSR > 1	0.0648	0.0838	0.77	0.43970
LSR < 1	-0.2180	0.0224	-9.72	0.00000

The minimum buy criterion, however, was significant, indicating that it adds approximately 68 percent to the price of a good bought by the DoD. Although this factor was not significant in the unweighted case, the magnitude of the unweighted effect of 67.3 percent (from Table 12) was nearly the same to the weighted finding of 67.9 percent. This indicates that violating a firm's minimum buy policy, whether the purchase is large or small in terms of total DoD value, significantly increases the cost paid by the DoD. This highlights the importance of the DoD consolidating its purchases and exploiting its buying power to avoid violating minimum buy policies.

When the Lot Size Ratio is less than one, the DoD significantly outperforms the average commercial sector firm by approximately 22 percent. This finding is consistent in sign with the stratification finding from the previous section (from Table 11, "Weighted" column, -14.6 percent), but the magnitude of the coefficient is larger in the regression because the Special Packaging and Minimum Buy factors are held constant. Overall, the finding indicates that when the DoD is a significant buyer in a market, certainly a buyer purchasing in larger quantities than the average commercial sector organization, they should expect to receive a better price.

4.5 Sensitivity Analysis of Electronic Sector Data

Two forms of sensitivity analysis were performed to develop insight into the robustness and dependence of the findings on the data comprising the electronic sector sample: 1) random removal and 2) price adjustment. Random removal consists of removing a part of the sample and re-performing the weighted price difference analysis, using the DoD and commercial wholesale prices, to determine the mean price difference and whether it is significantly less than zero. Price adjustment analysis incrementally lowers the commercial wholesale price of each purchase by one percent and re-performs the weighted price difference analysis to determine the mean price difference and whether it is significantly less than zero.

Random Removal: Random removal was performed to determine whether the findings remained in the DoD's favor as increasingly large, random segments of the data were removed from the sample. The analysis was performed by incrementally removing an increasing number of purchases from the sample as each analysis was performed. Since the sample is comprised of 329 purchases, purchases were removed beginning with five and incrementally increasing in sets of five until 300 purchases were removed. For each step of the removal process, 1000 simulations were performed; e.g., the analysis begins with the removal of five random purchases, weighted price difference analysis performed, the purchases are replaced, and then this process is repeated 999 more times. If the finding for a single simulation was not significant in the DoD's favor, then a counter was increased by one and the process continued. A separate count of the times where the commercial wholesale sector outperformed the DoD was also performed.

The findings for the electronic sector data are found in Figure 13. The findings reveal that once five to ten purchases are randomly removed from the sample there is no statistically

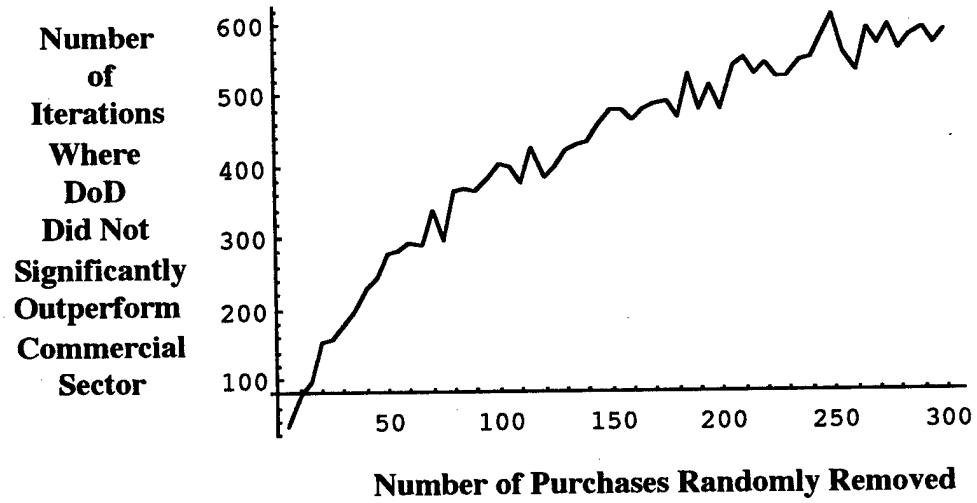


Figure 13: Simulated DoD Buying Performance as an Increasing Number of Purchases are Incrementally Removed From the Electronic Sector Sample (50 iterations is five percent of total simulations per adjusted sample size).

significant difference in buying performance between DoD and commercial wholesale sectors. This analysis indicates that the electronic sector findings are dependent upon certain purchases within the sample; i.e., the weighted price difference finding that the DoD significantly outperforms the average commercial sector organization within the electronic sample is not robust.

The random removal analysis was taken a step further to determine whether commercial wholesale buying ever significantly outperforms DoD sector buying within this sample. Figure 14 highlights the number of times per 1000 simulations the commercial wholesale sector outperformed the DoD. This analysis reveals that only after removing approximately 200 random purchases does the commercial sector outperform the DoD sector a *few* times every 1000 simulations. This finding, coupled with Figure 13, indicates that the electronic sector data is robust in the sense that there are not significant differences in performance between the two sectors once significant pieces of the data are removed from the sample. Collectively, the random removal findings reveal there is no evidence that the average commercial sector organization significantly outperforms the DoD.

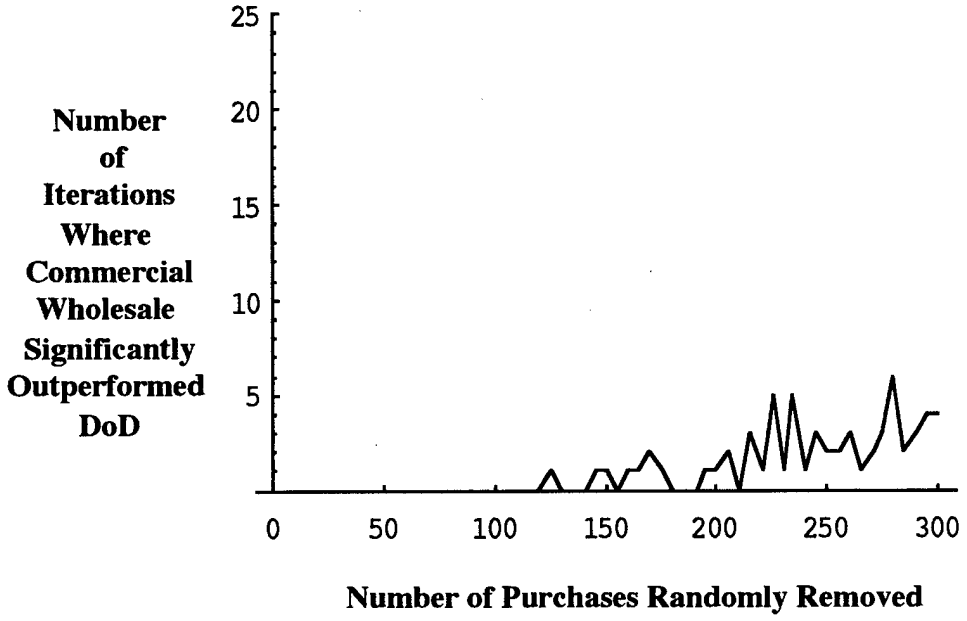


Figure 14: Simulated Commercial Wholesale Buying Performance as an Increasing Number of Purchases are Incrementally Removed From the Electronic Sector Sample.

Price Adjustment: The price adjustment analysis was performed to determine the uniform price adjustment at which there is no longer a statistically significant difference in DoD and commercial wholesale buying. Commercial wholesale prices were incrementally reduced by one percent of their original price in the sample until there was no longer a statistically significant difference in buying between the DoD and commercial wholesale sectors. The findings, found in Figure 15, reveal that commercial wholesale prices must be uniformly reduced by little more than one percent before there is no statistically significant difference between commercial wholesale and DoD buying. This means that the data collection process used to gather this sample would have to have imposed a systematic bias of at least one percent to reverse the finding that DoD buying significantly outperforms the average commercial organization buying at wholesale prices. A systematic bias of approximately 10 percent would have to be present for the commercial sector to significantly outperform the DoD within the electronic sample.

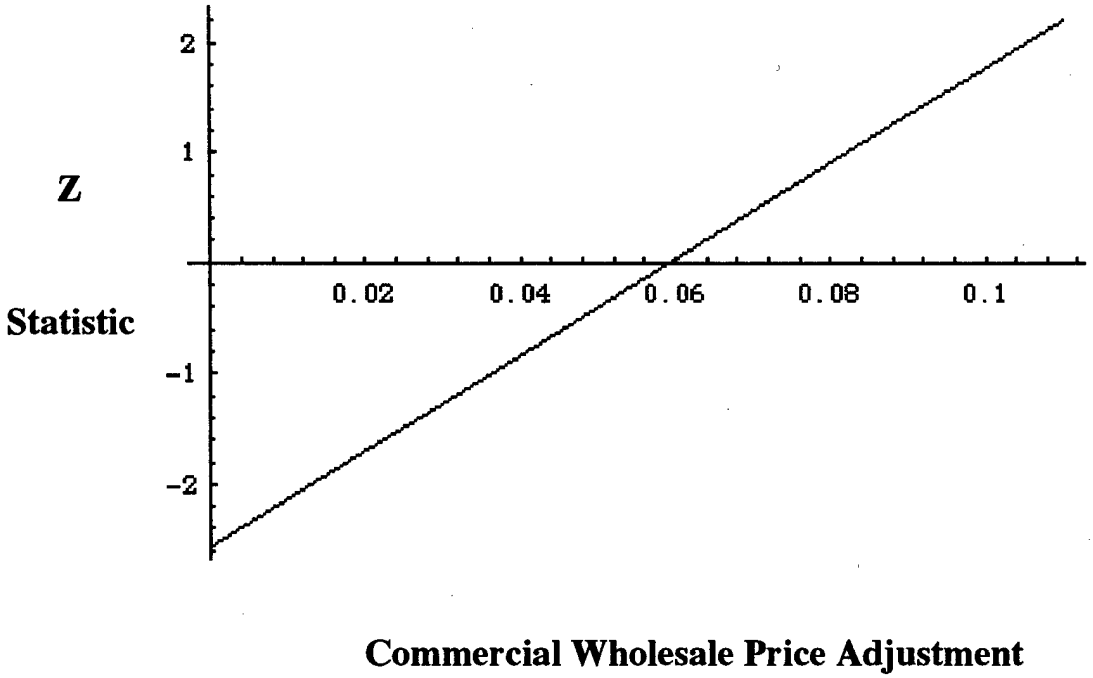


Figure 15: Change is the Z-Statistic as the Commercial Wholesale Prices are Incrementally Reduced.

4.6 Discussion of Electronic Sector Findings

Section 4.2 of this chapter presented evidence that the DoD outperforms the average commercial sector organization when a purchase is weighted by its contribution to total sample expenditures. This price adjustment has the effect of placing more importance on the larger dollar value purchases. The evidence that the weighted price difference is more favorable to the DoD than the unweighted price difference suggests that the DoD is paying more attention or taking greater care in buying more expensive parts or moderately expensive parts in large quantities. This finding invites a theory for DoD buying behavior more easily conveyed with the help of an analogy.

One can liken the DoD buyer to a consumer. If a needed item is relatively cheap and required in small quantities, then the consumer will put forth very little effort in obtaining a good price. For example, if one needs batteries for a flashlight, candy for the kids, or oil for a car, the typical shopper will go to one store and put forth very little effort deciding which brand to buy, perhaps buying the first prospect they come across. This phenomenon can be seen day to day on an ever increasing scale as *Seven-Elevens* or gas station food marts take up an increasing share of consumer grocery and beverage revenue. On the opposite extreme, however, is the consumer that needs to buy a new car, computer, or evening wear for a formal dinner. Under these circumstances, the average consumer may spend enormous amounts of time studying the product, possibly reviewing the manufacturer (informal certification), watching for when there is a sale (studying pricing behavior), and undoubtedly haggling with the salesperson to get the best price (negotiation). The typical DoD buyer and contracting officer are no different. They study, certify (validate that a supplier is qualified to provision the DoD), watch for sales, and negotiate with their suppliers when making significant purchases. On top of that, they are armed with a piece of legislation requiring the commercial sector to sell at prices no higher than the price received by their best commercial customer, though the DoD puts forth little or no effort to enforce that statute.

Many of the outliers in this sample can also be explained by the average consumer analogy. During this time, the DoD attempted to award purchases under $2500 to small businesses or minority-owned firms, including brokers. Whether the DoD's buying is as effective under these

circumstances may not be nearly as important as the greater societal and congressional goal of promoting small and minority-owned businesses. The average consumer also engages in this type of behavior several times a year when they buy Girl Scout cookies, candy bars for the local little league team, or cookies from the church bake sale.

Several of the avionics parts in this sample came from a female-owned company that only recently joined small and minority-owned businesses in receiving special status in DoD purchasing. Until that time, they routinely lost DoD contracts to brokers that were minority-owned businesses selling *their* parts at *higher* prices. In some cases, this female-owned firm had a lock on a DoD procurement in that their parts would be sold to the DoD, the issue was whether they or one of a number of brokers at higher costs would win the sale. The brokers were competing head-to-head with the actual manufacturer, the female-owned company, bidding the manufacturer's parts at a higher cost. The DoD routinely selected the brokers at a higher cost because of the larger societal goal of promoting minority-owned businesses. Whether one actually manufactures a part is sometimes irrelevant to the DoD. To the DoD, very often these purchases under $2500 are insignificant and, thus, not worth the effort to ensure the DoD gets a fair price.

This behavior by the DoD can be seen in the early Nineties when they instituted automated buying for all electronic purchases under $2500. Through interviews with buying personnel, it was learned that during its initial implementation many egregious buys were made through the automated system. Over time the software was made more sophisticated to catch firms taking advantage, but the buying activity as a policy chose not to go after the violators because it just was not worth the effort since the buys were so insignificant (less than $2500). This policy of treating purchases under $2500 as insignificant is being carried a step further within the DoD in the late Nineties with the policy decision that supply units will no longer handle non-weapon system purchases under $2500. The DoD leaders want local units to purchase whatever they need under $2500 using their organizational credit cards. Some units within the DoD will have the threshold for credit card usage raised to $25,000 during 1998. The leadership is empowering the operational units to exercise judgment and purchase effectively using their organizational credit card.

5.0 Engine Sector Findings

This chapter uses unweighted and weighted price analysis to examine purchases from the engine sector. In order to find a common basis of comparison, two engines were identified that are bought and sold in both the DoD and commercial sectors. For the DoD, the engine parts are bought at two different locations. Although both engines are sold to both sectors, the DoD owns a set of engineering drawings for some of the parts as well as possesses certified cost and pricing data for one of the engines. By owning a set of engineering drawings, the DoD is able to contract the manufacture of some parts with secondary suppliers if they are unsatisfied with the price or quality offered by the prime contractor and there exists a reputable, certified third party vendor capable of manufacturing the respective part. For this engine, the DoD is the largest customer for new engines and spare parts, but the DoD's business does not constitute the majority of revenue from this engine for this particular manufacturer. For the other engine, the DoD buys the parts discounted directly off of the commercial price catalog. Some parts, however, are duplicates of parts from other jet engines for which the DoD possesses certified cost and pricing data. In those cases, the DoD's discount is different and in every case far larger. For this engine, the DoD is an important but not near the largest customer of the respective manufacturer.

The prices paid by the DoD were gathered by visiting each buying activity and directly reviewing each of the contracts for a two-year period (1995-1996), although some of the contracts had deliveries into 1997 (parts bought with incremental delivery clauses). The commercial prices for one engine were gathered by visiting the prime contractor, meeting with their sales executives and learning the discount received by their best commercial customer off the commercial price catalog. This discount was 30 percent and the commercial catalog prices were discounted accordingly to arrive at the wholesale prices used in this analysis. Thus, for one of the engines, the DoD's buying performance is compared to the buying performance of the manufacturer's best commercial customer. The retail price for this engine is the catalog price. The catalog price is paid quite often by low volume commercial customers and the DoD when they have emergency buys that violate the manufacturer's lead time requirements. The sample of purchases for this engine

contained no such buys. For the other engine, two large commercial users (both very large commercial airlines) were contacted for the prices they pay for their engine parts. The two airlines are the largest and third largest commercial users of this particular engine [Schiavo, pp. 219-221, 1997]. The commercial airlines had to be contacted because the manufacturer was totally uncooperative in this research. The largest user of this engine pays the commercial catalog price for its parts and performs all repairs in-house. This price was considered the wholesale price. The other user, with a smaller number of this type of engine, paid 10 percent *above* the commercial catalog price and contracted out their maintenance of this engine. This price was considered the retail price.

5.1 Results of Unweighted Price Difference Analysis of Engine Sector Data

The engine sector data is comprised of 132 purchases by the DoD. The unweighted price difference analysis using wholesale prices as the basis of comparison reveals that the DoD receives a better price for all but one purchase. Overall, the DoD pays 31.7 percent less than the average commercial organization ($p < .001$). The histogram of unweighted price differences is provided in Figure 16. The histogram shows that the overwhelming mass of purchases possess negative unweighted price differences, indicating the DoD outperformed the average commercial sector organization in nearly every engine part purchase.

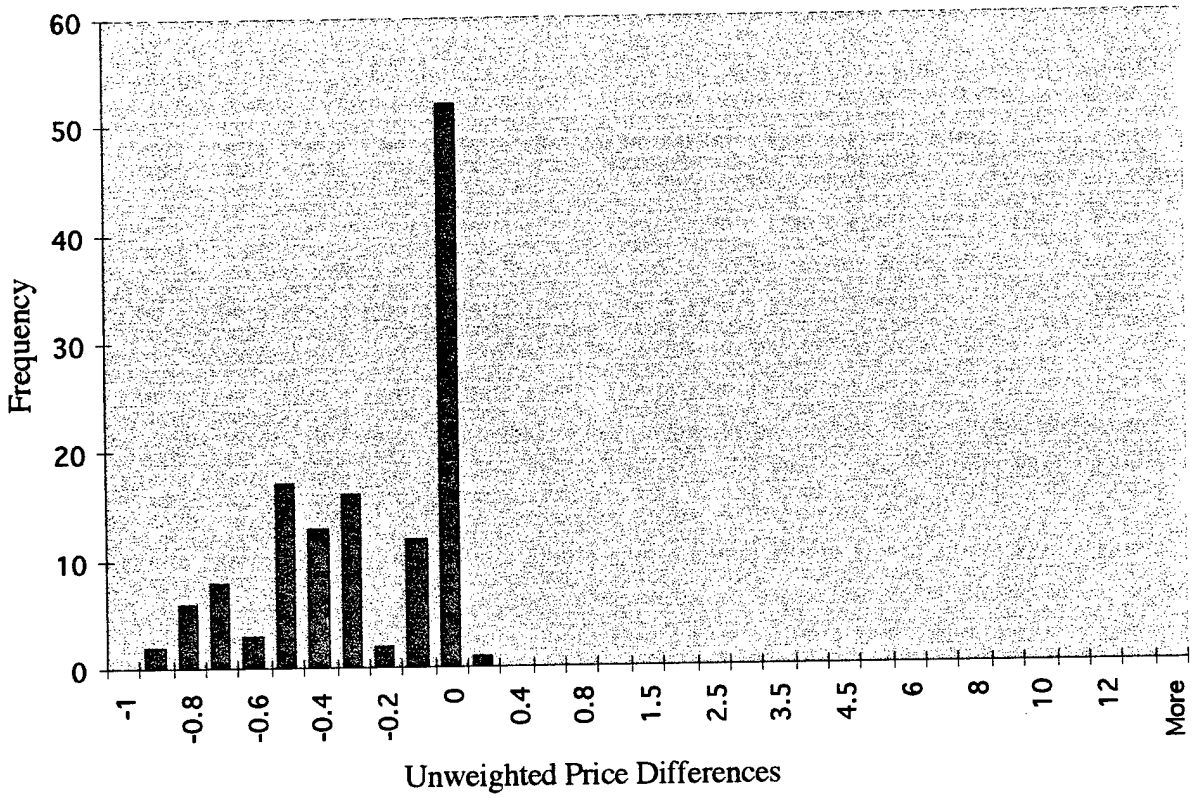


Figure 16: Histogram of Unweighted Engine Commodity Price Differences.

5.2 Results of Weighted Price Difference Analysis of Engine Sector Data

Weighting each purchase based on the total dollar value of each engine part purchase within the entire sample alters the previous section's findings. Once the price differences are weighted, the DoD pays on average 47.4 percent less than commercial wholesale prices ($p < .001$).

Aggregating all of the costs for each purchase and comparing the two sectors produces results similar to the electronic sector findings. The DoD's cost is $60.9 million to purchase the engine commodities comprising this sample. Using formula (4), it is found that the total commercial wholesale and retail costs are 106 and 193 percent *more*, respectively, than the DoD cost. These findings along with the unweighted and weighted findings for the engine sector are summarized in Table 14.

Table 14: Summary Results of Applying The Three Price Difference Formulas to Engine Commodities Data.

	Unweighted Price Difference	Weighted Price Difference	Total Cost Difference
Wholesale Prices	-31.7*	-47.4*	-105.5
Retail Prices	-43.6*	-62.7*	-192.6

*$p < .001$

5.3 Engine Sector Case Studies

This section takes the previous analyses a step further by considering other costs in the DoD's purchase of engine parts. Although the DoD has been shown to outperform the buying of the average commercial firm in the engine sector sample, there are other costs associated with DoD buying practices. There are labor costs associated with the buyers, contracting officers, item managers, their management, and the on-site personnel from the Defense Contract Management Command (DCMC) and Defense Contract Audit Agency (DCAA) that collect the certified cost and pricing data. Two of the case studies will consider these costs. A third case study will examine how the DoD's negotiation process uses certified cost and pricing data to squeeze profit from the prime contractor using a sub-sample of the first engine's data. This research handicaps the DoD's costs by assuming the counterpart commercial purchasing costs are free, although these costs undoubtedly exist in some form in the commercial sector.

Engine Case Study One: First Engine

This case study will consider the labor costs associated with the 71 different parts purchased by the DoD for $59.3 million over a two-year period to arrive at a more realistic estimate of the DoD's true buying costs. These adjusted costs are then compared to the commercial sector's purchase cost for the same parts at commercial wholesale and retail prices. The commercial

wholesale price is the price paid by the manufacturer's best commercial customer of the respective engine. The commercial retail price is the commercial catalog price. This is a further handicap of the DoD's position since the average commercial sector firm will not receive the same discounts off of the commercial list price that the most favored commercial firm enjoys.

The firm or prime contractor for these parts had $630 million in total 1994 sales for all of its engines and associated parts manufactured at the visited site with 55 percent of the revenue derived from the government. Two visits were made to this firm to interview their management, review the singular manufacturing line producing both the commercial and military engines, and interview the DoD's on-site managers, inspectors, and auditors. Interviews with the firm's senior management revealed that their most profitable segment of the business was the sale of spare parts. Like their counterparts in this industry, they use deeply discounted engine sales to achieve market share. Sometimes they may even lose money in order to penetrate a new market with an engine and secure the more lucrative spare parts business that grows as the engine is used and maintained.

To identify the full picture of the DoD's buying costs, the buying activity was also visited. The contract files were reviewed and the prices and quantities of each purchase were verified by reviewing each contract. Through this visit, it was found that this engine is supported by four contracting officers on a part-time basis, although the 71 purchases comprising this sample were made by only three of the contracting officers. Support on a part-time basis means that they also act as buyers and contracting officers on other engines purchased and at this buying activity. Assisting these contracting officers on a part-time basis were four requirements officers, four item managers, and four engineers. All of these individuals support the purchase and management of other engines and their subordinate parts.

At the defense plant, there were Defense Contract Management Command (DCMC) and Defense Contract Audit Agency (DCAA) personnel that supported this manufacturing line on a part-time basis. The DCMC personnel consisted of an Administrative Contracting Officer (ACO), two price analysts, one engineer, and one manager. The DCAA personnel consisted of two auditors. Collectively, there were 23 people that affected either the buying or the manufacturing of

these parts for the DoD on a part-time basis. Follow-up interviews in person or over the phone were conducted with many of the principals involved in the earlier interviews. In every case, including the manufacturer's personnel, it was echoed that allocating the full labor costs for 23 people over two years to these purchases was an overstatement of the DoD's real cost.

To arrive at a maximum DoD labor cost for these parts, this research assumes that all 23 people oversaw the purchase and manufacture of these parts on a full-time basis; thus, all of their labor costs over the two-year period comprising this sample are allocated to this analysis. The cost of a labor-year was assumed to be the cost the Air Force pays for one Member of the Technical Staff (MTS) from one of its engineering support contractors: $180,000. This was a fully loaded rate, covering salary, benefits, travel, amortized office space, and administrative and managerial overhead. This rate is approximately $70,000 more than the Air Force charges for organic resources at its two system and software design centers. So the $180,000 rate for a staff year and the allocation of all labor costs for the personnel to this analysis are further handicaps to the DoD's cost position.

The final segment of the case study computes the DoD's labor costs for this sample, adds them to the DoD's cost for purchasing the parts comprising the engine sample, and compares them to the commercial wholesale cost of the same parts. The DoD's total purchase costs are:

Contracts for 71 parts:	$59.3 million
Labor costs over two years:	$ 8.3 million
Total DoD Cost:	$67.6 million

The commercial wholesale cost for the same parts, using the discount the manufacturer's best commercial customer receives, is $123 million. After considering labor costs, the DoD's processes and workforce were still able to pay $55.4 million less than the average commercial organization. If the DoD had purchased these same parts directly off of the commercial catalog, then the DoD would have paid $176 million. Within this sample, the DoD's processes and workforce saved $108.4 million by not buying parts using commercial catalog prices.

This case study highlights the potential hazards of buying spare parts strictly off of commercial price lists as well as the need for the DoD's buying organizations to measure their purchasing performance relative to the commercial sector.

Engine Case Study Two: Profit Taking by the Manufacturer

Within the "first engine" sub-sample of 71 purchases or contracts, detailed manufacturer profit information was found for 57 of the purchases. The other 14 contracts were for less sophisticated parts, so the DoD's buying activity sought full and open competition in the manufacture and purchase of those parts with the primary and secondary manufacturers. The contracting record under these circumstances did not contain any information related to estimated profit. The DoD will sometimes seek secondary production sources for typically less sophisticated parts when they perceive the prime contractor is asking too high a price for a part. The buyers and contracting officers strongly prefer sticking with the prime manufacturer because too often the parts from a secondary source fail to meet their performance requirements.

The DoD collected certified cost and pricing data for the 57 purchases, so the DCMC personnel (on-site DoD personnel) had a reliable estimate of the firm's actual cost for manufacturing each part. As part of the negotiation process, the DoD was able to assess the firm's target profit from their initial price position and negotiated profit based upon the final price. From these figures, one can then derive the profit associated with the commercial wholesale prices for each part.

It was found that the firm's target profit varied between 8.8 and 34.3 percent within this sub-sample, with a weighted average mean target profit of 20.5 percent. The final negotiated profit varied between 7.9 and 26 percent, with a weighted mean negotiated profit of 13.8 percent. Extrapolating from this analysis, the profit associated with the commercial wholesale prices varied between 21 and 322 percent, with a weighted mean profit of 55.2 percent. In the aggregate, the primary manufacturer's target, negotiated, and commercial wholesale profit associated with the 57 contracts comprising this sub-sample is $11.9, $7.9, and $31.8 million, respectively.

These findings reveal that the DoD's negotiation process was able to reduce the firm's profit through negotiation by $4 million. This profit is assumed a minimum because imperfections may exist in the certified cost and pricing data potentially hiding additional profit for the firm. It is clear, nevertheless, that possessing certified cost and pricing data enhanced the DoD's position in getting a fair price from the firm. The DoD does not seek to arbitrarily minimize profit. To determine the reasonableness of a firm's proposed profit, the DoD audit team or auditor will perform a detailed analysis based on, for example, amount of labor, cost of labor, cost of capital, and risk in manufacturing to determine a fair profit target to pay a firm.

The typical negotiation finds the firm presenting a worst-case scenario for the manufacturing of a part and other aspects of the contract. They are trying to insert the notion of risk into the minds of the DoD's negotiators. The firm is seeking to maximize the negotiated cost and profit. Once the contract is signed, the firm then seeks further efficiencies in manufacturing to realize a greater profit from each contract.

Another interesting aspect of this case study is the difference between the aggregated commercial wholesale profit and the firm's aggregated target profit. The commercial wholesale prices are those prices that the firm's best commercial customer pays for parts. For this sub-sample of 57 contracts, the firm's profit taking using commercial wholesale prices would have been $31.8 million. The mere presence of DoD auditors and negotiators caused the firm to propose only $11.9 million in profit, a difference of $19.9 million. Once negotiations were completed, the DoD saved an additional $4 million. When one factors in the associated maximum DoD labor costs of $8.3 million over the two-year period, the DoD saved $15.6 million in profit. Within this anecdote, the cost of DoD oversight personnel is outweighed by the savings they bring to the DoD.

Engine Case Study Three: Second Engine

This particular engine makes for an interesting case study. Not only is it interesting from an economic point of view, but it also reveals how senior industry officials wield influence in and

around Washington. This engine was originally pursued purely as a case study because it was discussed briefly as part of an anecdote in Rich and Janos' book, *Skunk Works*. The anecdote in the book alleges the DoD pays 20 percent more than the commercial price for the same engine, buys the engines with no warranty, and has 300 DoD inspectors on the production line [Rich and Janos, p. 325, 1994]. This is the kind of anecdote that the media loves to flaunt; however, it possesses several objective features that could be verified or refuted.

After nearly four months of informal and formal requests to the firm to visit the site and evaluate the manufacturing line first-hand, this approach was abandoned and a visit was negotiated through the DCMC office overseeing the DoD manufacturing within the plant. Although the senior managers for the DCMC office were not familiar with the Rich and Janos anecdote, they were very familiar with the intense, cyclical scrutiny they have received over the years because of this particular engine. Senior officials in the DoD and Congress have repeatedly criticized this DCMC office and initiated inquiries because of perceived excessive DoD oversight on this engine's commercial manufacturing line.

The reality of the situation is that there is not and has never been any oversight by the DoD on the manufacturing line cited by Rich and Janos. In fact, the DCMC personnel are not even allowed in that section of the facility. DCMC personnel are only allowed in the military engine portions of the facility. This was verified during the site visit to this manufacturing facility. This commercial engine line is fenced off from the DoD engine lines and DCMC personnel do not have access. This manufacturing line is essentially the same as the line producing the engines associated with Engine One, where military and commercial engines are assembled seamlessly on the same line by the same personnel.

The labor records for this DCMC office were reviewed over the previous ten years. The maximum DCMC labor allocation for the entire manufacturing facility was only 161 people. This occurred in 1987 at the peak of the Reagan military build-up when this facility had nearly 19,000 people working on or supporting various manufacturing lines. It is impossible for the DoD to have had 300 people on any of this firm's manufacturing lines, let alone a commercial engine line. The

warranty issue was also investigated and found to be false, with the DoD buying some type of warranty that varied by contract. In terms of engine price, the DoD pays essentially the same price as the commercial sector for a whole, new engine. Since the manufacturer refused to take part in this research, the biggest commercial buyer of this engine was contacted and they provided the prices they paid for their most recent purchases of this engine, occurring in the same year as the DoD's purchases.

Despite these realities, the scrutiny by industry and congress of this DCMC office has been intense and unrelenting over the years because the manufacturer actually has a different agenda: they want the DoD personnel out of the portions of the plant building high performance military engines. They want the DoD to quit collecting certified cost and pricing data for the high performance military engines. The firm has used lobbyists to create congressional outrage by misrepresenting the oversight the DoD applies in this facility. The firm recognizes that reducing oversight within the plant will lead to higher profits.

5.4 Discussion of Engine Sector Findings

The engine sector findings provide further evidence the DoD buys more effectively than the average commercial sector organization. The unweighted versus weighted price difference analysis of the engine sector data complements findings from the electronic sector, indicating the DoD more carefully considers larger dollar value purchases. In general, this finding is consistent with long standing government policy. The checks and balances the government requires for purchases increase as the dollar value of a purchase increases.

In the engine sector, the DoD primarily increases its attention to high dollar value purchases by taking four approaches: 1) collecting certified cost and pricing data, 2) seeking secondary sources for the manufacture of less complex parts, 3) purchasing a two- to three-year supply of a part with a scheduled monthly delivery rate that matches anticipating utilization, and 4) negotiating price breaks off of a manufacturer's catalog prices. At the time the Engine One data were collected, requesting certified cost and pricing data from sole source manufacturers was a common

occurrence, even when the parts were found in a commercial catalog. These purchases were also different from Engine Two because the DoD owned a set of engineering drawings from which their manufacture could be competed among secondary suppliers. The certified cost and pricing data significantly enhanced the DoD's bargaining position with the prime manufacturer. Furthermore, using the direct labor costs identified in Case Study One, though undoubtedly high because of the assumptions, the DoD spent approximately 12.3 percent of the total cost on item management, collecting certified cost and pricing data, negotiating with the prime manufacturer, and buying the engine parts. This figure appears excessive in light of the Coopers & Lybrand/TASC [1994] study's finding that collecting certified cost and pricing data accounts for only 1.3 percent of the cost of an item; however, caution must be exercised using that finding since that study's sample size consisted of only 10 firms and relied on interviews rather than objective financial evidence. Regardless of what is the correct figure, taking the worst case scenario, the DoD saved $108.4 million by collecting certified cost and pricing rather than purchasing the parts out of the commercial catalog.

Breaking the less complex parts out for full and open competition in their manufacture is another path the DoD took with some of the engine part purchases in the Engine One sub-sample. This approach is, however, a doubled-edged sword from the perspective of the DoD's item managers and contracting officers. Although it almost always guarantees the lowest prices, it does often create situations in which ill-prepared firms win contracts and eventually default because they are unable to deliver the level of quality required by the DoD. The contracting officers abhor breaking out complex parts for manufacture to secondary firms because the norm is an underperforming secondary development firm that must either be rescued by the primary manufacturer or the DoD must wait longer than expected to receive their parts in order for the secondary manufacturer to "get it right." Getting rescued by the primary manufacturer is not always a simple or economic solution, however, because the DoD will more often than not wait until their inventory becomes critically short and then violate the primary manufacturer's delivery requirement for adequate lead time for delivery. This violation will cause the DoD to pay a

premium or the commercial catalog price. In the past, regardless of the existence of a litany of problems with secondary manufacturers, the contracting officers were under tremendous pressure from the DoD leadership and congress to use alternative manufacturers via full and open competition.

Another key feature of the DoD's buying efficiency with the Engine One sub-sample was the coordination and planning of the manufacture of the vast majority of parts with the primary manufacturer. The purchasing and manufacturing was planned over a couple of years with incremental deliveries to the DoD. This creates a "Win-Win" situation for the DoD and the manufacturer. For the DoD, it allows them to derive the benefits associated with aggregating their buying power while receiving incremental deliveries to cover anticipated utilization. This second facet is an important money saving feature because it minimizes the DoD's inventory and is a form of the commercial practice of "just-in-time" delivery. For the primary manufacturer, this sort of coordination and sale to the DoD customer allows them to more effectively plan their purchase of raw steel, refinement of raw steel, and utilization of their machine shop resources, especially in relation to their commercial sector business which is by no means as stable.

A fourth DoD method for saving money in a purchase or group of purchases is the negotiation of a discount off of commercial catalog prices. This approach was taken by the DoD's buyers for the Engine Two sub-sample. For most of the parts, the DoD enjoyed a discount of 7.5 percent off of the commercial catalog price. This manufacturer's largest commercial owner of this engine, pays commercial catalog prices while the second largest commercial user of this engine pays 10 percent above the commercial price. Interestingly, several of the DoD's part purchases in this sub-sample enjoy as much as a 70 percent discount off of the commercial catalog price. This is occurring because those parts are duplicates of spare parts off of a militarized engine for which the DoD possesses certified cost and pricing data. Again, when the DoD collects cost and pricing data, they enjoy even greater savings compared to their counterparts in the commercial sector.

The most important conclusion arising from the case studies is that the DoD's processes add value under certain circumstances. This is an important public policy finding because the DoD

or, more generally, the federal government is going through an unprecedented push to commercialize every facet of their procurement business. There is a very strong push within DoD and from industry to reduce or eliminate oversight, outsource or streamline buying through the use of commercial catalogs, and embrace commercial buying practices. Within the DoD, the Coopers & Lybrand/TASC study has been the research base supporting many of the reform initiatives, but that research provides an incomplete picture and caution should be exercised when applying its findings.

These case studies highlight the hazards of overlooking the benefits of oversight and regulation as well as the DoD's direct procurement costs. A "one size shoe fits all" public policy of removing DoD oversight or buying strictly out of commercial catalogs will lead to higher industry profits and higher DoD costs. Less oversight equates to less insight into a firm's operations. The challenge for the DoD is to find the right balance between oversight and industry profits. This balance could be achieved through an intense measurement program across the DoD's buying activities. Each buying organization should possess analyses revealing how they are performing relative to the commercial sector. The DoD leaders, armed with these analyses, need to use a scalpel to trim inefficiencies rather than commercialize every process and abolish all oversight personnel.

6.0 Purchase of Commercial Software Products

It is believed that the Department of Defense (DoD) spends approximately 30 billion dollars a year on software [DSMC, 1990]. The vast majority of this funding is spent either purchasing or developing custom software; however, a growing segment of DoD software expenditures is the purchase of Commercial-Off-The-Shelf (COTS) software products to satisfy various mission requirements. These are products, sometimes referred to as shrinkwrapped software, that are bought and sold in the commercial marketplace. The DoD as well as the commercial sector are looking more earnestly at these products to satisfy key organizational functions because they offer the prospect of lower purchase and life cycle costs when compared to their alternative, custom software.

This chapter extends this dissertation into the realm of software commodities. Software commodities possess several unique features different from the electronic and engine sectors. First, with software commodities there seems to be no notion of a wholesale versus retail price structure. Prices vary significantly depending upon quantity, time of the year, and whether a vendor is interested in penetrating and then dominating a new market. Software salespeople have these luxuries because software really has no manufacturing cost. The cost to bring a software product to market is a sunk cost once a salesperson begins to sell a product; thus, cash flow problems or end-of-quarter sales reporting to shareholders plays an important role in the price offered to a customer. Second, the DoD is organized differently in the way it buys software commodities. This affects the overhead that must also be considered for a fair comparison. Third, software vendors give away significant amounts of ancillary software with large sales. These inducements appear to further solidify the vendor's penetration in a market. This phenomenon will be examined more closely in this chapter.

6.1 Background

A sample of software commodity purchases was collected from the Air Force. The software commodities comprising this sample are primarily sold in the commercial sector, although

the DoD is a large customer for many of these vendors. The Air Force, like the other military services and the General Services Administration (GSA), often enters into exclusive commodity contracts either directly with a vendor or through a third party that acts as an integrator for the government. An integrator will oversee, coordinate, or integrate the efforts of other vendors or programs to form pieces of a larger DoD system or infrastructure. The software commodity sample was collected from 57 contracts the Air Force awarded through an integrator for the purchase of 232 products in various quantities valued in excess of $36 million. The contracts were all awarded between January 1 and September 30, 1996. Although this was an Air Force initiative, in keeping with recent acquisition reform initiatives, other military services and agencies of government were also permitted to purchase software commodities through this integrating contractor.

Purchasing software products for the Government was only a small part of the integrator's responsibility. The integrator was also responsible for delivering to the Air Force a comprehensive system and software engineering environment, including appropriate hardware. Cascading from this responsibility was engineering effort to test and integrate the products comprising the system and software engineering environment. For this research, only the software commodity purchases were examined during the aforementioned nine-month period. Hardware, hardware maintenance, and software maintenance contracts or purchases were not considered.

The commodities comprising this sample consist primarily of database, networking, and system management software, products that typically make up various facets of a client/server or web-based architecture. This is the emerging architecture as companies, universities, and governments migrate from proprietary mainframe hardware and software systems to open system environments. Despite the presence of an integrator providing a system and software engineering environment, many of the contracts consisted of competing products as some governmental organizations preferred, for example, Oracle to Sybase relational database management products.

The sample was collected by visiting the Air Force's buying office over a series of days and directly reviewing all software contracts between January 1 and September 30, 1996. A total

of 65 software contracts were found. For each of the products, four prices were gathered: actual Air Force purchase price, commercial list price, Air Force contract price, and GSA price. Eight of the contracts were excluded because complete information related to pricing was not present in their records. The eight excluded contracts consisted of 21 products purchased in varying quantities worth approximately $1.5 million. The remaining 57 contracts consisted of 232 product purchases valued at approximately $36 million using the government's purchase price.

The basis of comparison for this analysis are the differences between the actual Air Force price and the other prices. These price differences are further analyzed by computing the mean price difference to determine who is the better buyer, using the same approach as that found in previous chapters.

The four prices for each product were gathered by reviewing each contract record. In most cases, commercial prices were found from the vendor's proprietary price list found within the contract record. One vendor, however, provided commercial list prices for approximately half of their products. The Air Force buying activity analyzed these prices to determine the average mark down from commercial list price to Air Force contract price. In every case it was a mark down in price. This average mark down was used to determine the commercial list price for the products not in the vendor-provided price catalog. The Air Force contract price is the price advertised within the DoD and across other government agencies, although these prices were seldom if ever the actual purchase price.

The third price recorded was the GSA price. This price was captured as a surrogate to a commercial wholesale price. The GSA is the central buying organization for the federal government, although other agencies are permitted to enter into their own contracts for specific products. The GSA enters into contracts with many commercial vendors in order for the federal government to aggregate their buys and get the best price from the commercial sector. For a few of the vendors, the GSA price was computed in a fashion similar to the estimates of commercial list price: the average discount of the known GSA prices was used for the unknown products.

The last price is the actual price paid by the government for a product within a particular contract. The actual price paid by the government was not always the price that was negotiated by the integrator with the vendor. For example, one contract called for a vendor to provide 128 copies of its server product, 128 copies of its distributed option, and 10 copies each of its two development environments. The total contract value was approximately $289,000; however, the vendor offered as an inducement to close the deal within a time window a $29,000 discount. This discount was then distributed back into the total contract cost, diminishing the price proportionately for each product. These new prices were the actual prices paid by the government.

6.2 Commercial Software Product Findings

Several analyses were performed to determine which price yielded the least cost to the customer. The first analysis multiplies the purchase volume for each contract by each of the four prices and then sums the individual products to arrive at the total cost for all contracts. Table 15 shows that the government's actual cost is less than if the government had paid either commercial list, contract, or GSA price.

Table 15: Total Cost of Software Commodity Sample Using Each Type of Price

	Government Actual	Commercial List	Government Contract	GSA
Total Cost	$36,351,811	$88,400,126	$57,849,034	$60,534,926

A price analysis was then performed on an item by item basis within the sample using the Government Actual and GSA prices. The unweighted price difference model was used to determine the price differences. Because the GSA is the government's central buying activity consolidating government purchasing power, one may assume that GSA prices are a good surrogate for commercial wholesale prices. It was found that on average the DoD Actual unweighted prices are 19.7 percent less than the GSA prices; however, once the price differences are weighted, the DoD Actual prices are 34.2 percent less than the GSA prices ($p < .001$). If one

assumes that GSA prices are reflective of the average commercial organization, then the DoD is buying software commodities on average more effectively than the average commercial organization. A histogram of the unweighted price differences is presented in Figure 17. The histogram reveals that in terms of price, the government is receiving a better price in nearly every case. The results of the unweighted and weighted price difference analyses are summarized in Table 16.

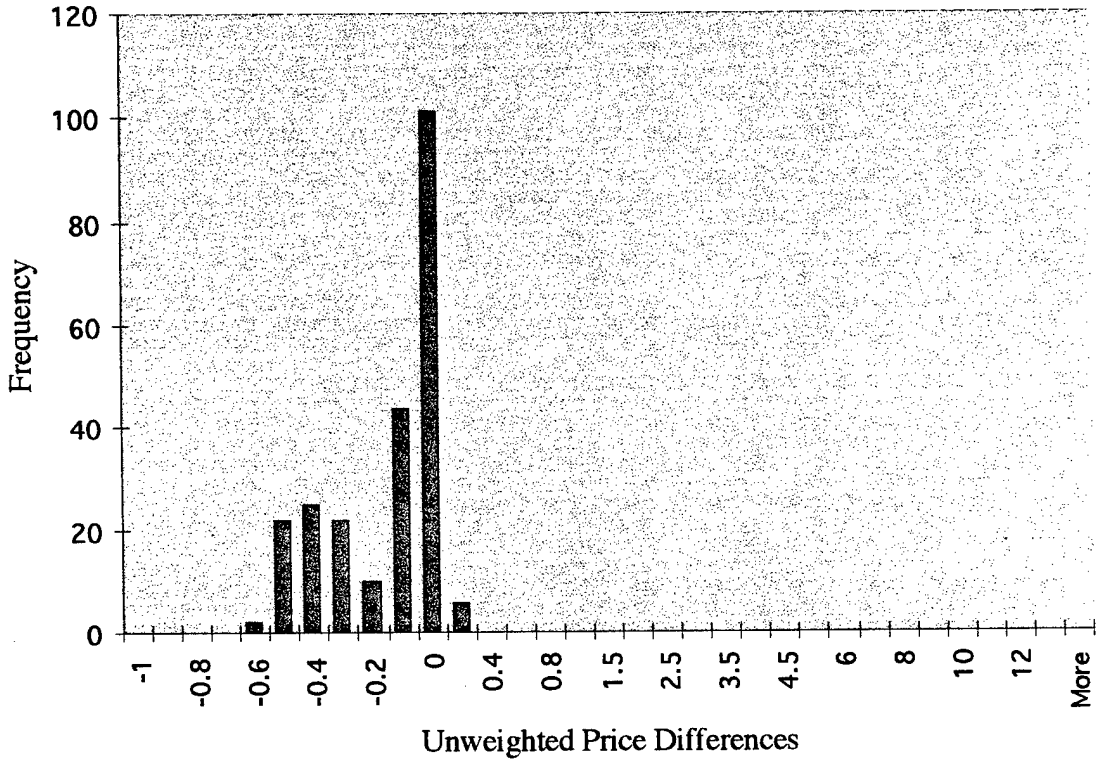


Figure 17: Histogram of Unweighted Price Differences Between DoD Actual and GSA Purchase Prices of Commercial Software

Making the assumption that GSA prices are a reasonable surrogate for commercial wholesale prices introduces some risk in interpreting the software findings; however, it is a sound assumption in view of the absence of reasonable alternatives as well as the disadvantage it imposes on the DoD in the analysis. First, in making this assumption, it is assumed this is the price the average rather than the best commercial firm pays. Certainly in the software industry, particularly in the client/server sector of the software marketplace, the collective US Government is the single

largest customer. The GSA is the buying organization for the US Government. It is unreasonable to assume that the average commercial sector organization possesses the buying power of the US Government. Therefore, by making the assumption that the average commercial sector firm buys at GSA prices, the DoD is being placed at a disadvantage in this analysis. Second, the volatile pricing behavior of the software vendors in this market makes the determination of a commercial wholesale price a daunting task. Timing, market buying power, and the possibility of a new market all play a role in pricing. The GSA assumption provides a conservative surrogate. Third, vendor cooperation was not forthcoming. In fact, one vendor opined that the only cooperation any would provide would be nothing more than a review of the finished product to see whether they could learn anything about their competitors. One vendor went so far as to ask whether a dialog had been established with a competitor and whether the analysis would be provided to them. Information related to pricing and selling behavior is often viewed as proprietary information by commercial companies.

Table 16: Percent Difference in Price between DoD Actual and the Other Prices

	Commercial List		Government Contract		GSA	
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Price Difference	-41.4*	-53.7*	-16.5*	-30.9*	-19.7*	-34.2*

*Statistically significant from zero, with $p < .001$

6.3 Discussion of Software Sector Findings

The findings reveal that the DoD is buying better than either the average governmental organization (GSA price) or those commercial organizations buying at commercial list prices. How does the DoD do it?

First, like industry, this Air Force buying activity has studied its suppliers. They know that certain vendors offer the best prices near the end of certain financial quarters, particularly those quarters where sales are lagging investor expectations. In the view of the Air Force buyers,

extraordinary offers are made quite frequently with small windows of time for acting on the offer in order for the vendor to boost sales to meet some target. The buyers claim to wait for these offers. The Air Force has even coined the term "specials" to identify when a software vendor has deeply discounted an offer.

The second reason the government does well is that the Air Force and other governmental organizations buying from this Air Force contract are aggregating their buys. As the buys are aggregated and a sale becomes significantly larger for a vendor, they discount the prices to a far greater degree than the prices found on the GSA price list, which is supposed to represent a pooled discount rate for all of government. Here, the DoD is exploiting its purchasing power. For example, the Air Force used this contract to buy all of the software required to modernize the DoD's personnel systems with commercial database management technology. All of the buying was done centrally through this contract with three buys over a six-month period ($5, $2, and $5 million, respectively). The Air Force could have bought these products on an individual Air Force site basis in much smaller quantities over many more contracts, but they never would have realized the same savings. On a site or air base by air base basis, the DoD would have had approximately 350 individual purchases: approximately 100 active bases and 250 guard and reserve sites. Each site would have required some human involvement. Such an approach would have been onerous on the DoD and the vendor because of the overhead associated with managing so many licenses from one vendor and for one customer, respectively.

Third, the Air Force has established an organization as well as hired an integrating contractor to help it organize (aggregate) its buys, study vendor selling behavior, and get the best price for not just the Air Force customer but for all government customers using this initiative. However, these efforts are not free to the taxpayer. Throughout 1996, the Air Force's buying office was staffed by approximately 16 people and they paid their integrating contractor $5.2 million over the nine-month contracting period spanning this data sample. A fair cost comparison must consider these costs.

Whether one is a commercial or DoD buyer, it costs money in terms of labor to purchase these products. However, although it is unrealistic, this analysis assumes that commercial buying costs are zero. Commercial buying costs are outside the bounds of this research. The Air Force buying activity is now what the government calls a fee-for-service organization. Consequently, they know their costs reasonably well in order to charge other government organizations for their services. This organization charges their other customers approximately $110 thousand per staff-year (this is a fully loaded rate, which means it includes travel and any associated office costs). Thus, the Air Force buying activity's cost over the nine-month buying period comprising this study is $1.32 million ($110 thousand times 16 people times 9/12 of a year).

The more difficult cost to ascertain is the cost of the integrating contractor. The Air Force was paying the integrating contractor $1.188 million a month during 1995, but only a small percentage of their effort entailed buying products. The vast majority of their effort was devoted to engineering, testing, and maintaining the products comprising the system and software engineering environment they were required to deliver to the Air Force. A good surrogate for their costs could be what the Air Force is paying the integrating contractor in 1997, where the Air Force has discontinued all engineering and testing activities. During 1997, the integrating contractor is only providing buying assistance for commercial software and hardware products. In 1997, the government program office is slated to pay the integrating contractor approximately $1.2 million for the entire fiscal year. However, to limit argument, this analysis will assume that 50 percent of the integrating contractor's cost over the nine-month period in 1996 are attributable to buying activities. Thus, the integrating contractor's cost pertinent to this research is $2.6 million ($5.2 million times 50 percent). Table 17 aggregates these costs to give a more accurate picture of the costs to the taxpayer to buy the products comprising this sample.

Table 17: Cost of Software Commodity Sample After Considering Labor and Contract Costs

	Government Actual	Commercial List	Government Contract	GSA
Software	$36,351,811	$88,400,126	$57,849,034	$60,534,926
Labor	$1,320,000	$0	$0	$0
Contract	$2,600,000	$0	$0	$0
Total Cost	$40,271,811	$88,400,126	$57,849,034	$60,534,926

Even with the additional Air Force labor and contract costs, the analysis reveals that, in terms of total cost, the Air Force is still better than organizations buying using commercial list prices by nearly $50 million and other governmental organizations by more than $20 million. Again, if the GSA price is representative of the price the average commercial organization is paying, then the Air Force is buying software products more effectively than the average commercial organization.

Lastly, paying commercial list or the retail price is not an unusual occurrence for either the DoD or commercial sector. Many of the buys in this sample were bought by the DoD at commercial list price because of the small quantities involved.

6.4 Incentives

One of the more interesting aspects of the software sample is the large amounts of software given away by the vendors as inducements to close a sale or ensure their product penetrates a new market. All together, the vendors gave away 83 products in varying quantities valued at more than $26 million using government contract prices (government contract prices are in almost every case less than or equal to GSA prices). Many of the products were essential to the architecture being acquired by the respective government customer. One could argue that there is a downside to the government's acceptance of this free software because it perpetuates or facilitates a dominant vendor position in that segment of the government market. This section examines the selling

practices of two software vendors to see how they use free software inducements as an attempt to penetrate and dominate the government market.

An interesting aspect of the incentive products was how one database vendor, the vendor that is a distant second place in the DoD market in terms of market share, used two contracts worth approximately $2.4 million to give the Air Force more than $10 million in free additional software. More importantly, the free software came in quantities larger than the actual sale, indicating that the vendor is trying to get the Air Force to use their product in more than the currently planned areas. The software vendors, like their counterparts in the hardware industries, know that the real money in selling systems is in selling future upgrades or spare parts [Vandivier, 1972]. The vendor knows that getting more customers to use their products today will translate into additional revenues tomorrow through product upgrades or license renewals. This was not the only example of this behavior.

The dominant database vendor in the government market also gave away enormous amounts of software, but their approach was to sell the run-time products and then give away the development tools in varying quantities. For five of the six contracts where they gave away software products, they gave away one or more development environments and in every case they gave away a data browser of some type. These are important products because each of these products are what their direct or development customers see. The expensive server-based database engines are transparent to the using customers. Thus, the vendor sees two customers in this circumstance: a using customer, or the users of a system; and a development customer, or the individuals that develop the systems using the commercial products. The using customers interact with the system through a data browser. The vendor's development customers see and use the development tools. The vendor's strategy is to sustain the penetration of this market by making all of their customers happy and comfortable using its products so that when upgrade or license renewal time approaches, the customers will stay with their product line. Developers and users of systems dislike more than anything else to learn a new system or development environment. If the customer stays with the development environment or the client interface tools (data browser), then

the customer must also stay with the server-based database engine products that comprise the vast majority of the cost of a database management system. The customers are hooked by the products they use even though the real money for the vendor is upgrading the server products that are really transparent to most of the customers.

The incentives provide real capability for the government customer. Although on the surface it appears a vendor is giving away significant value with an incentive package, what they are giving away they expect to gain back many-fold in deferred compensation. There is a trade-off the government customer must manage when accepting and then using free software products. The cost is really deferred. The government customer needs to consider these deferred costs when evaluating a system's life cycle cost. For the vendor, the zero manufacturing cost and resultant near-infinite supply of software enables their sales personnel to employ creative strategies for gaining and then sustaining a market.

7.0 Aggregation and Analysis of All Sector Data

This chapter aggregates the data from each sector to examine the DoD's overall buying performance compared to the average commercial sector organization. The basis of comparison is commercial wholesale prices versus prices paid by the DoD. For software sector data, GSA prices are used as surrogates for commercial wholesale prices. The aggregated data in this analysis are 693 purchases for more than 831 thousand items valued at more than $99 million using the DoD's purchase prices.

The analysis method utilized in the previous chapters was again employed on the aggregate data. The histogram of the unweighted price differences is provided in Figure 18. This histogram highlights the distortion of price differences to the detriment of the DoD. Price differences in the DoD's favor are constrained between 0 and -1, while the commercial sector's prices vary between

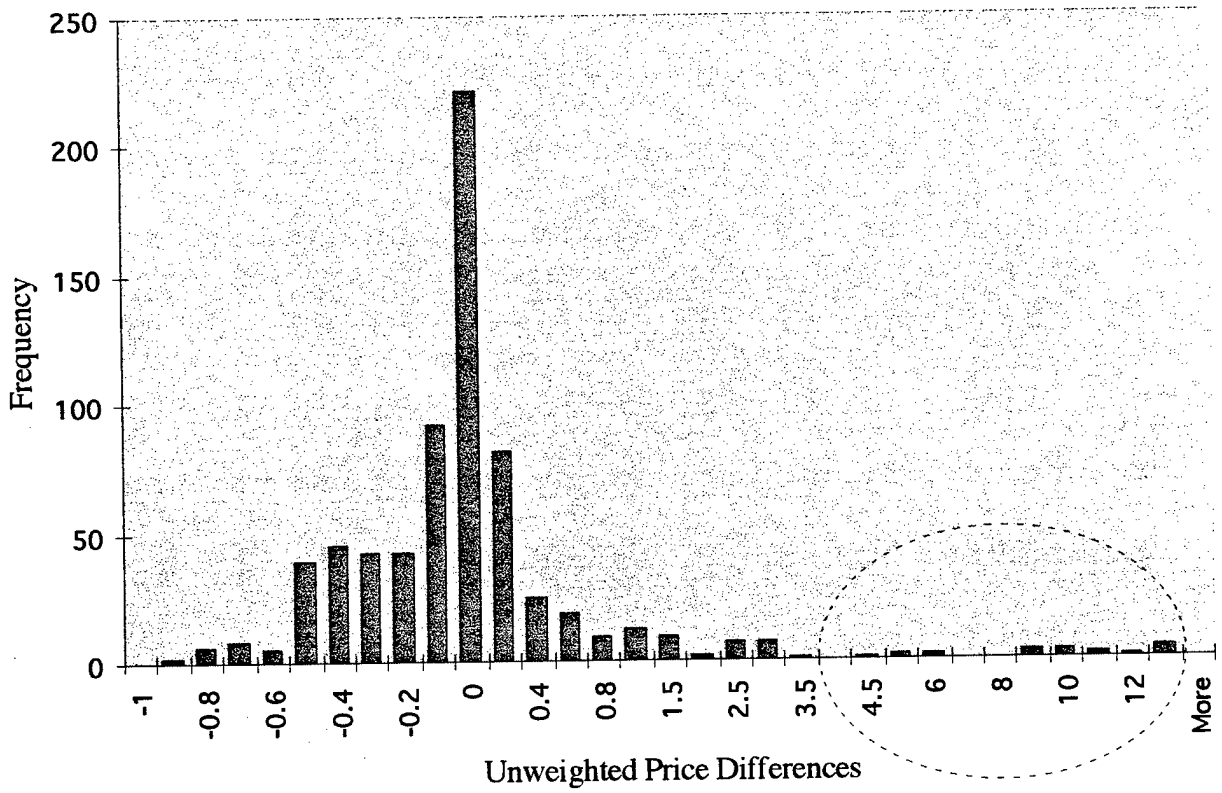


Figure 18: Histogram of Unweighted Price Differences Between DoD and Commercial Wholesale Purchase Prices For All Commodities

0 and infinity. In terms of unweighted price analysis, it was found that the DoD paid 20.7 percent more than the average commercial sector organization ($p < .001$). The dashed ellipse highlights the many egregious buys made buy the DoD. These are purchases in which the DoD paid from 450 to nearly 1300 percent more than the average commercial sector firm buying at wholesale prices. These purchases are the kinds of anecdotes that sometimes become a source of embarrassment for the DoD.

The purchases were then weighted and the histogram is provided in Figure 19. This histogram clearly shows what happens when the purchases are weighted: there is a shift in mass to the left as the larger dollar value purchases become more prominent. The outliers identified with the ellipse in Figure 18 disappear because they were comprised of low dollar value purchases in relation to the entire sample. The weighted price difference analysis reveals the DoD pays 41.5 percent less than the average commercial sector organization ($p < .001$).

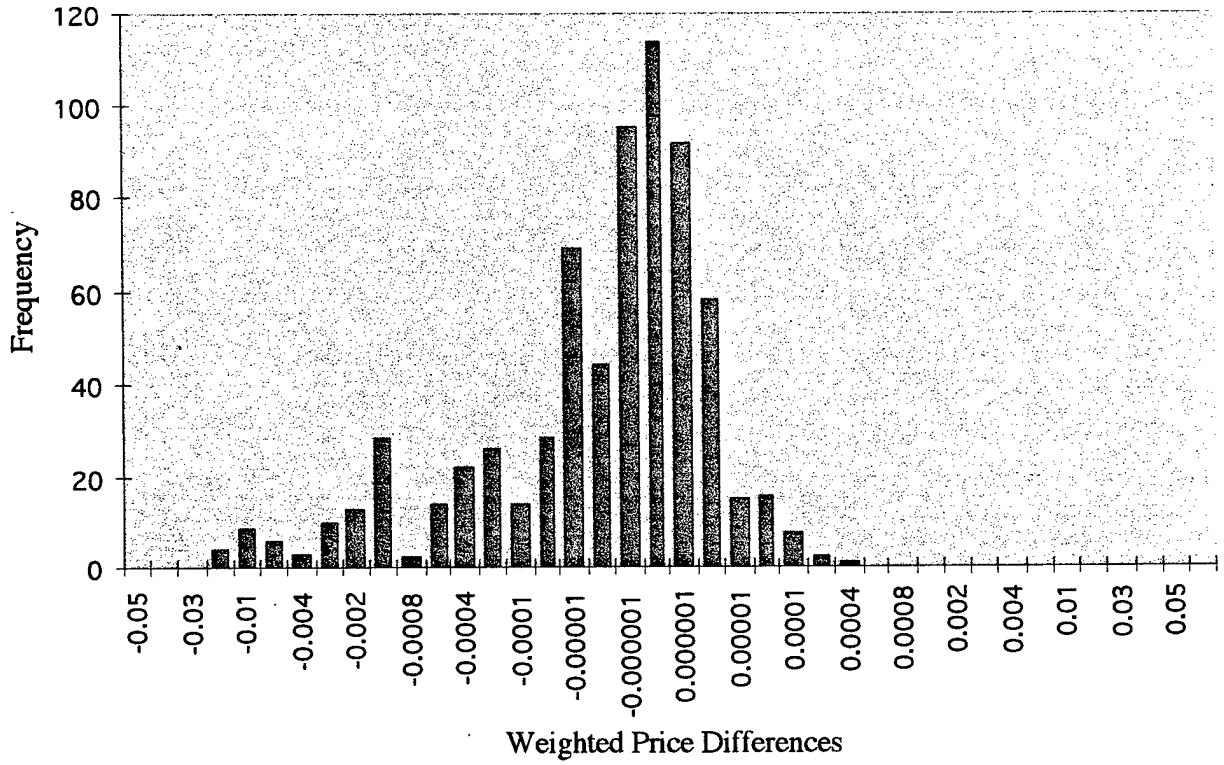


Figure 19: Histogram of Weighted Price Differences Between DoD and Commercial Wholesale Purchase Prices For All Commodities

Across all of the samples, the items purchased by the DoD for $99.9 million would have cost more than $188 million if the DoD had used commercial wholesale prices. In the aggregate, the DoD paid approximately 89 percent less than the average commercial organization purchasing the commodities comprising this sample at wholesale prices. Table 18 juxtaposes these findings with the findings from each sector. In every case, the DoD's total purchase cost was less than if commercial wholesale prices had been used (% Diff column of Table 18).

Table 18: Summary of DoD Purchasing Performance and Costs by Sector

	Price Analysis Summary*			Value of Purchases**		
	% Diff	Unweighted	Weighted	DoD Cost	Wholesale	Retail
Electronic	-14.4	70.2	-5.9	2.7	3.1	4
Software	-66.5	-19.7	-34.2	36.3	60.5	88.4
Engine	-105.5	-31.7	-47.4	60.9	125.1	178.1
Total	-89	20.7	-41.5	99.9	188.7	270.5

*Percentages using the three price analysis methods

**In millions of dollars

These findings cogently capture the flaw in comparing unweighted price differences. Examining only price differences distorts the DoD's actual buying behavior. Even though several of the individual purchases contributing to the perceived poor DoD buying performance would make good anecdotes for the evening news or a tabloid article, they were of inconsequential value to the DoD. A more realistic assessment of the DoD's buying performance is found by weighting the purchases according to purchase volume, revealing that the DoD within the samples gathered as part of this research outperforms the average commercial sector organization when purchasing commodities.

The DoD's buying behavior is sharply captured by plotting all of the purchases based upon the unweighted price difference and total DoD contract value of each purchase. In terms of total DoD cost, the purchases range from less than a dollar all the way up to approximately $5,000,000. The range of unweighted price differences begin just over a -100 percent and climb to over 1200 percent. All of the purchases are plotted in Figure 20 (See end of Chapter 7). The scatterplot reveals that the vast majority of purchases are in the DoD's favor, falling in the 0 to -100 percent

range in terms of unweighted price difference. The plot also highlights the distortion in the unweighted price difference method. Those purchases where the commercial sector outperforms the DoD are permitted to vary between 0 and infinity while DoD purchases that outperform the commercial sector are only allowed to vary between 0 and -100 percent. The scatterplot also reveals the more than a dozen purchases in which the DoD paid more than 500 percent above commercial sector prices, yet those purchases were for trivial amounts. These are the same outliers identified by the ellipse in Figure 18.

Figure 21 probes deeper into the sample of purchases by examining those purchases that amount to less than $200,000 in total DoD contract value and less than 300 percent in unweighted price difference. The vast majority of the purchases are still less than zero in terms of unweighted price difference, especially nearly all of the high dollar value purchases. Figure 22 magnifies the examination of the sample even higher, focusing on all purchases less than $20,000 in total DoD contract value. The majority of purchases are still less than zero, but a scattering of purchases are beginning to appear in the range of unweighted price difference where the commercial sector outperforms the DoD.

Figure 23 examines all of the purchases less than $2500 with an unweighted price difference less than 600 percent. The $2500 limit was used because it was the threshold in which the human buyer's presence ended and the automated buying process took over within the electronic sector sample. Here it becomes evident that the DoD is not purchasing nearly as well as they were for the high dollar value purchases. The majority of purchases are in the positive price difference range, indicating the average commercial sector firm is outperforming the DoD.

These figures provide graphical support to the proposition that the DoD cares little for small dollar value purchases while focusing its attention and effort on the high dollar purchases. Whether the purchase is for high dollar value electronic, engine, or software commodity purchases, the DoD receives a price that is more often than not lower than that received by the average commercial firm buying at wholesale prices.

7.1 Discussion of All Sector Data

This dissertation has presented evidence supporting the proposition that the DoD takes greater care in purchasing as the total dollar value of a contract increases. The findings from the earlier chapters summarized above in Table 18 lend partial support to this proposition. This section will examine the performance between sectors to see if they provide further theoretical support.

The DoD buyer must take into consideration the total potential cost when contemplating a purchase. At the time of contemplation, the contract has not been awarded and there does not yet exist an agreed upon purchase price between buyer and seller. There is typically, however, a commercial list, catalog, or retail price for the particular item, so the DoD buyer can compute a cost potential. Another way to look at the phenomenon of the DoD buyer paying more careful attention to more expensive purchases is by examining the buying performance in terms of cost potential of a contract or individual purchase. A corollary to our proposition that the DoD provides more careful consideration as the cost of a purchase increases is that those sectors with the greatest potential cost per purchase or contract line item should provide the greatest purchasing efficiency by the DoD.

The three sectors are now compared on the basis of the mean potential cost per contract line item. To arrive at these figures the total commercial retail cost of each sample is divided by the number of items in each sample. For the electronic, engine, and software sectors, the mean potential cost per contract line item in millions of dollars is $.012, $1.35, $.381, respectively. Since the mean potential cost is greatest for the engine sector, our theory predicts this sector should be the most effective at buying. From Table 18, we know the engine sector pays on average 47.4 percent less than the average commercial sector organization using weighted price differences. The engine sector provides the best buying performance by the DoD, as predicted by the corollary. The smallest potential value per contract is found within the electronic sector at approximately $12,000 per item. Our corollary predicts this would be the sector with the poorest buying performance. Table 18 supports the corollary with the electronic sector outperforming the average commercial organization by only 5.9 percent using weighted price differences. A test of means was performed

between the electronic and engine sectors' mean weighted price differences and it was found that they were significantly different ($p < .001$).

The average potential cost of each software sector purchase was greater than the electronic sector's and less than the engine sector's mean potential cost. Our corollary predicts that software sector buying by the DoD should exceed the electronic sector while lagging behind the engine sector. Table 18's weighted price differences supports this hypothesis. The software sector outperformed the average commercial sector firm by 34.2 percent using weighted price differences. A test of means between the software and electronic sectors confirms that the software sector's mean weighted price difference was significantly less than the electronic sector's ($p < .001$). Similarly, a test of means between the software and engine sectors confirms that the engine sector's mean weighted price difference was significantly less than the software sector's ($p < .001$). Both findings lend support to the proposition that the DoD is more careful in purchasing items of greater dollar value.

Another finding lending support to the proposition that the DoD pays greater attention or takes greater care as the total dollar potential of a contract increases can be found by stratifying the engine sector data to determine if one buying activity outperformed the other. The engine sector data is comprised of engine buys from two different activities for two different engines. In terms of the DoD's cost, the sub-sample of the first engine consists of 71 purchases worth $59.2 million and the second engine sub-sample consists of 61 purchases worth $1.6 million. In terms of potential mean dollar value per contract, the first engine's costs are $2.5 million ($176 million commercial retail cost divided by 71 purchases) and the second engine's costs are $34,300 ($2.09 million commercial retail cost divided by 61 purchases). Thus, the corollary predicts that the DoD's purchasing of parts for the first engine should be more effective; i.e., the weighted price difference for the first engine should be less (more negative and thus more effective) than that of the second engine.

The engine sector sample was stratified and the weighted wholesale price difference computed for each sub-sample. The first engine's weighted wholesale price difference indicates

the DoD is paying 48.3 percent less than the average commercial sector firm ($p < .001$). The second engine's weighted wholesale price difference is 13.0 percent less than the average commercial sector firm ($p < .001$). A test of means revealed that buying for the first engine significantly outperformed buying for the second engine ($p < .001$). The buying of parts for the first engine was significantly more effective. This finding provides further support to the theory that the DoD's buyers on average take greater care and are, thus, more effective at buying items of higher value.

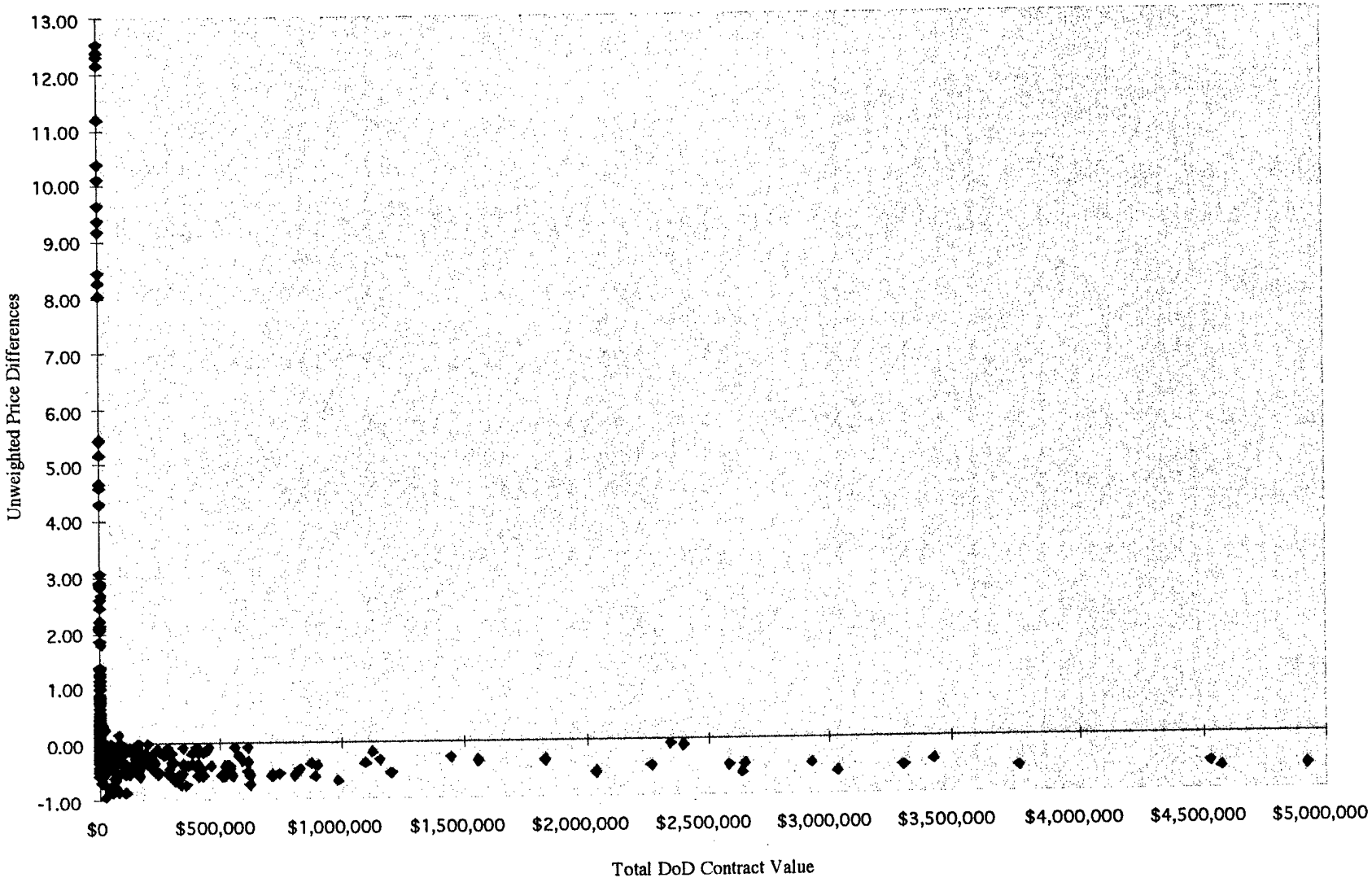


Figure 20: Scatterplot of All Purchases by Total DoD Contract Value Versus Unweighted Price Differences

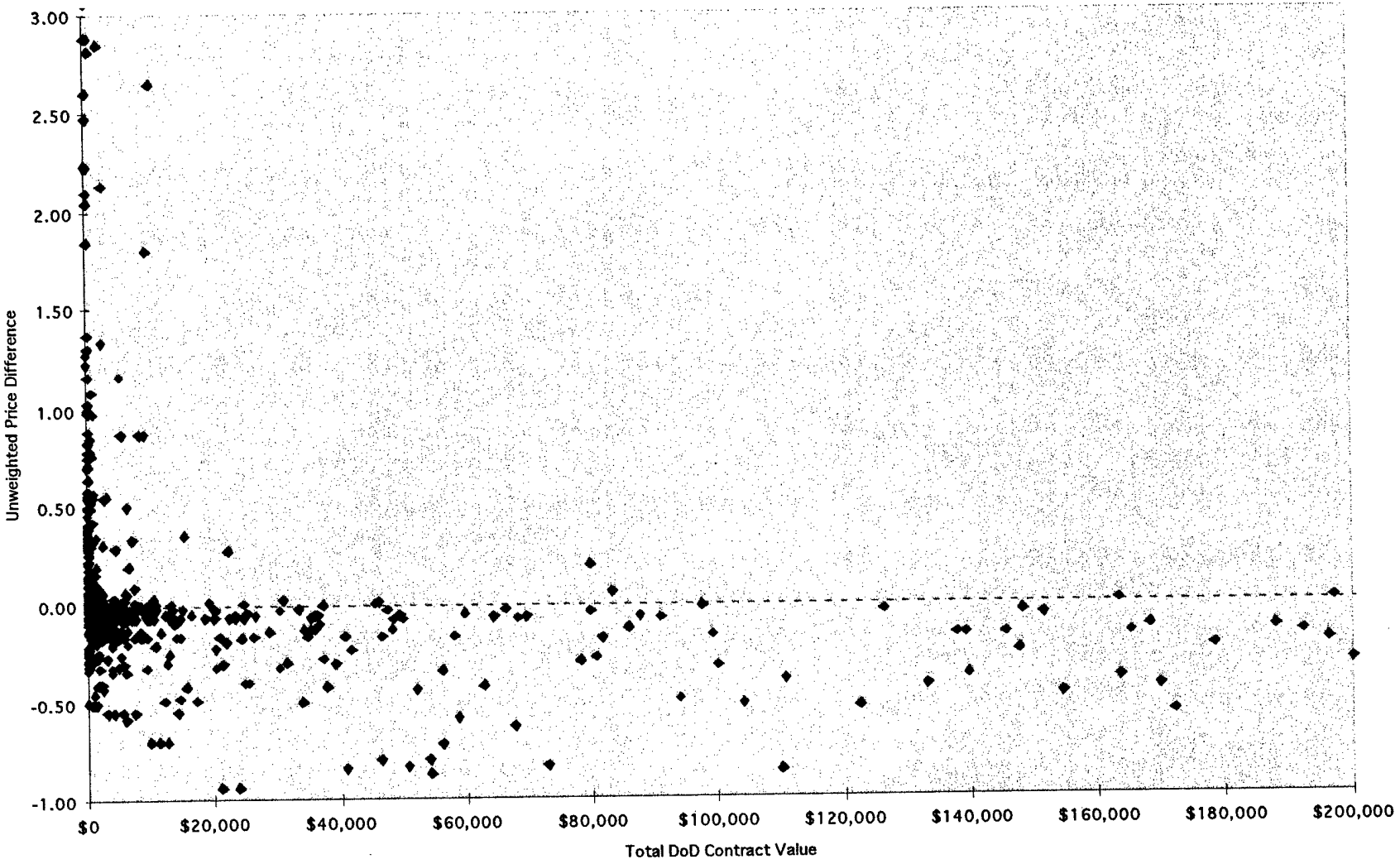


Figure 21: Scatterplot of All Purchases Less Than or Equal to $200,000 by Total DoD Contract Value Versus Unweighted Price Differences Less Than or Equal to 300 percent

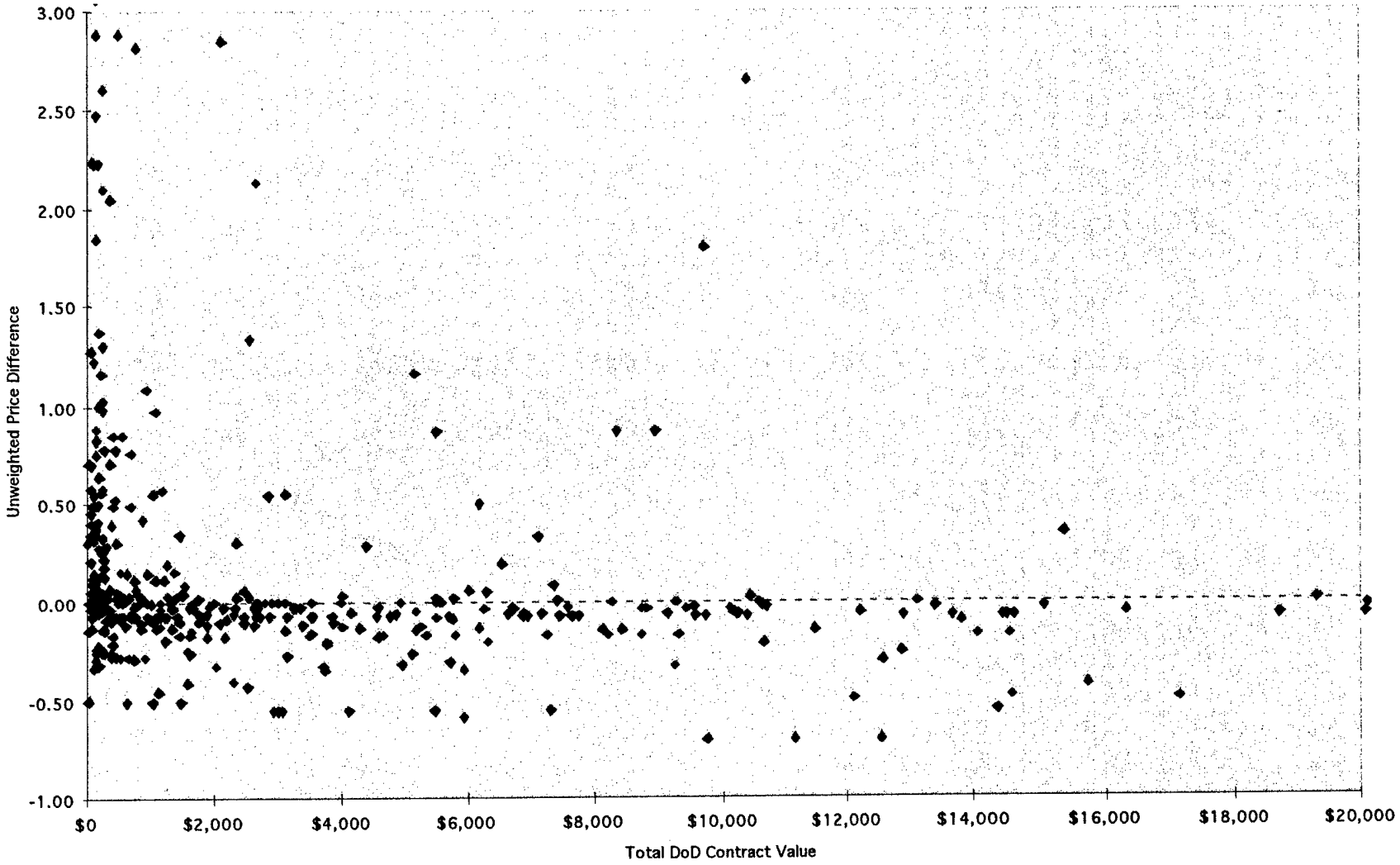


Figure 22: Scatterplot of All Purchases Less Than or Equal to $20,000 by Total DoD Contract Value Versus Unweighted Price Differences Less Than or Equal to 300 percent

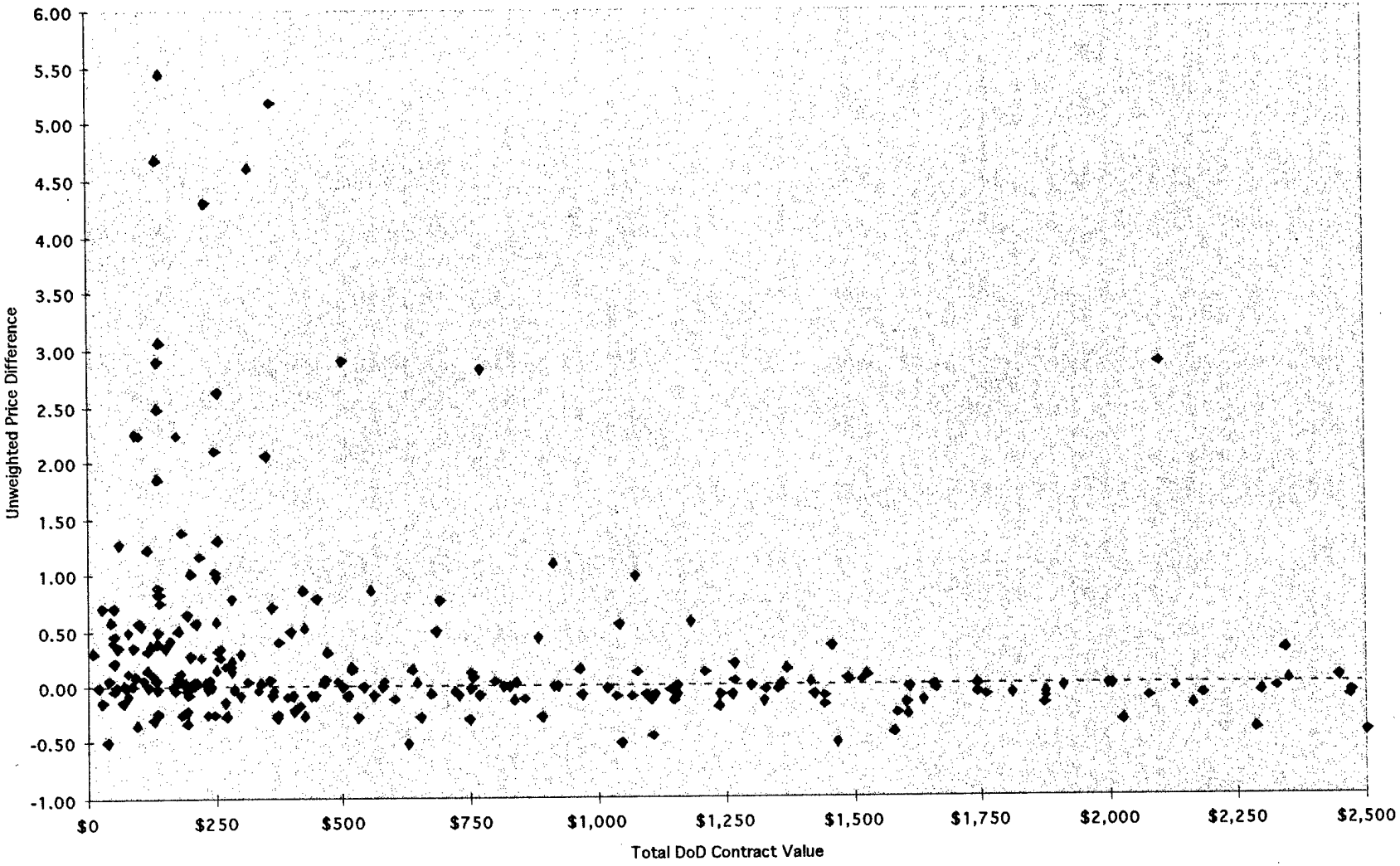


Figure 23: Scatterplot of All Purchases Less Than or Equal to $2500 by Total DoD Contract Value Versus Unweighted Price Differences Less Than or Equal to 600 percent

8.0 Prospects For Future Research

Defense procurement has provided a fertile bed for public policy research for the last 50 years and will continue to do so in the future. As long as enormous sums of public money are expended by the DoD there will exist a perception in the public's eye that there are endless opportunities for efficiency. While the DoD buyer or contracting officer has a fiduciary responsibility to ensure effective use of taxpayer dollars within their individual domain, it will remain the province of the public policy researcher or social scientist to act as an honest broker and perform macro-level analyses to evaluate the DoD's efficiency and offer appropriate remedies. This dissertation opened the door a little wider to the world of defense purchasing, raising innumerable possibilities for continuing this research.

8.1 Commercialization of Labor

A study of DoD labor costs is the single most important follow-on to this dissertation. This dissertation examined the DoD's purchase of commodities within certain sectors. Essentially, the DoD is also purchasing various types of skilled labor to perform its logistics functions, contract buying, acquisition management and engineering, and computer hardware and software support. The current administration has embarked on deep cuts in organic resources performing these jobs with the goal of outsourcing these jobs. The problem is that a cost-benefit analysis supporting such cuts in many cases do not exist. Again, the DoD's penchant for "one size shoe fits all" public policy is taking the commercialization push into the realm of eliminating military personnel and civilians in favor of contracted personnel. Outsourcing has become a tremendously popular commercial sector practice, so the DoD's commercialization leaders have embraced it enthusiastically. The question that requires answering is whether the DoD's leaders have done their homework. Is the DoD's labor cost structure at a high enough level that they can replace organic resources with contracted personnel and save money? The DoD's leadership certainly believes this is true.

One of this dissertation's data collection efforts provided insight into this problem. The organization that provided the software commodity sample also possesses a large organic software development workforce. To give the reader a feel for the proficiency of this software organization, they

are a "certified level 3 organization" using the Software Engineering Institute's Capability Maturity Model. Less than five percent of the software organizations in the world have been evaluated at this *high* a level, so they may not be a perfect software organization, but they are certainly doing a good job relative to their peers in government and industry. The majority of their organic software workforce are Air Force enlisted and officer personnel. It is no secret that enlisted and officer personnel make far less than their counterparts in industry. Taking into account the cross-section of talents and ranks, this organization charges other DoD units $52 an hour for its services. This is a fully loaded rate taking into account salary, benefits (including retirement), facilities, and travel. On the very first modernization program requiring outsourcing of software development, this same organization is paying their contractor $90, $125, and $140 an hour for the key engineering and software development labor categories, and these rates do *not* include travel, facilities, overhead, or profit.

Anecdotes like that above abound across many of the military's career fields. Carefully crafted studies are required by career field because assumptions in one career may not hold in one or more other career fields. Similarly, commercial sector findings should be carefully analyzed before uniform application across the DoD. Within the commercial logistics sector, for example, outsourcing is a prevalent behavior; however, the vast majority of that outsourcing is in the area of transportation rather than in purchasing, supply, and maintenance [KPMG, 1998]. The DoD needs to carefully consider this finding and commercial sector experiences before outsourcing every facet of logistics, for that is not the norm in the commercial sector.

8.2 Generalizability of Findings Across All of Defense Purchasing

One of the ultimate goals of a public policy researcher is to study a small, well-constrained area or problem, discover something new or verify an existing relationship, and then generalize that finding to a more general problem or larger arena. A key weakness of this dissertation is the lack of insight into whether these findings hold for other sectors or the much larger body of purchases within each sector. Although this dissertation is a vast improvement over the anecdotes typically exploited in the literature, one is still left wondering how much is spent by commodity sector each year by the DoD. This is a weakness

not from a lack of trying, but from a lack of reliable cost figures from the DoD of how much is spent each year within the electronic, engine, software and other commodity sectors. Arriving at a reliable estimate of these costs would be a monumental research task in itself. The DoD is plagued with hundreds of different cost accounting systems hindering an accurate integration of the costs within the various commodity sectors.

The largest segment of defense purchasing is the system procurement sector, where the large weapon systems like the C-17 cargo aircraft or the Air Force's newest fighter, the F-22, are procured. One may certainly not generalize the findings from this dissertation across the system procurement sector. The performance of the system procurement sector is certainly a ripe arena of study using a case study approach, particularly after the many procurement reforms of the late Eighties and early Nineties and the drawdown in government acquisition personnel. Most of the case studies in the literature are from procurements in the Fifties and Sixties with a smaller number from the early Eighties. An interesting topic of study would be the effect of commercialization within a large system procurement. Has the purchase of commercial items really reduced costs within a large system procurement?

The findings from this dissertation were drawn chiefly from the electronic, engine, and software commodity sectors. Would the findings from this dissertation hold-up in other sectors? The DoD purchases enormous amounts of computer hardware, all types of equipment (pumps, generators, fork lifts, trucks, etc.), maintenance contracts for all types of equipment, hardware for aircraft, training, and engineering support.

During the background discussion of DoD purchasing in Chapter 3, the difference between the purchase of initial spares packages and the more typical purchasing done at a buying activity or depot were explained. Many of the egregious part buys in the past have occurred as part of initial spares packages. An interesting study would be to determine whether the DoD was any more effective buying initial spares packages. This would be a challenging research endeavor because initial spares packages are typically comprised of system-unique components. It could turn out to be difficult to find identical parts sold in the commercial sector.

Though it may be difficult assessing the DoD's performance buying initial spares packages, understanding this performance is especially important at this time because, for several of its large systems, the DoD is going to allow its prime contractors to provide contractor logistics support (CLS) for all system unique parts. The prime contractor will now be responsible for the purchase or fabrication of parts, their supply, and subsequent insertion into the system when required by maintenance. Under these circumstances, the DoD is not only paying a contractor for a part, but they are also paying them to buy the part, store it, and then use it to fix a system. The DoD's leadership believes CLS will save funding, but robust studies examining the DoD's full cost picture are sorely lacking. The commercial sector is embracing the outsourcing of the transportation function within logistics; however, most commercial companies are keeping the core, critical logistics functions in-house [KPMG, 1998].

8.3 "I Have Faith in God, All Others Bring Data"

The title to this section is a famous quote by Dr. W. Edwards Deming, the great quality guru of this Century. Although this dissertation is important for showing that the DoD does some purchasing well, its more important role should be one of motivating real measurement and cost-benefits analyses of the DoD's innumerable purchasing or acquisition activities. Recent scholarly efforts directed towards defense procurement have tended to focus on the need for outcome-based management and deregulation; i.e., abandon slavish adherence to processes in favor of making common sense process changes that will yield more efficient purchasing [Wholey and Hatry, 1992; Gore, 1993; Moe, 1994; Thompson and Jones, 1994; Kravchuk and Schack, 1996; and Mayer and Khademian, 1996]. Some researchers, however, argue the opposite because they view outcome-based public policy as an erosion of executive branch power, public law, and a threat to some of the key goals of the government since its inception (fairness and accountability) [Moe, 1994].

Nevertheless, within the multiple commodity purchase sectors of the DoD, the various buying organizations should measure and seek to continuously measure their buying processes. This research and the associated measures should be extended into those domains to initially baseline current effectiveness in relation to the commercial sector. Experiments should be initiated to better understand how changing,

"commercializing," or outsourcing an operation affects a buying activity's performance relative to the commercial sector.

Experimentation is extremely important before embarking blindly into deregulation. The DoD's processes have evolved over time for good and bad reasons. Change for change's sake does not guarantee the DoD will become a more effective buyer. More importantly, what precisely constitutes "deregulation" or "commercial practices" has been conspicuously missing from the literature. Claims on the merits of "deregulation" and "commercial practices" have continually been made without any substantive data to back them up. Thompson summarizes the dilemma facing the DoD the best:

> "Regrettably, the case for deregulation is based primarily on experience with a few programs, most of them secret. Evidence that secret programs were on average more efficient and effective than other programs when they were burdened with fewer bureaucratic gatekeepers and less congressional scrutiny and micromanagement would be extremely useful. But we don't really know that they were. Neither do we know for certain that they have become less efficient on average because their management has become more bureaucratized. All we have to go on is hearsay. Indeed, most of what we think we know about acquisitions is based upon anecdotal evidence from case studies." [Thompson, 1993]

In a nutshell, the above citation reinforces the importance of this research and this section's proposed extension. A program of measurement, experimentation, analysis, and then change would put the DoD on the right path towards Deming's dictum and providing a foundation of rigorous data for public policy researchers to make more rational recommendations.

8.4 Affect of Customer's Share of Seller's Market on Price

A factor that was undoubtedly affecting the price a customer received within the samples this dissertation employs was the percentage of the seller's business a customer enjoys. In every case where the DoD outperformed the average commercial sector firm, were they also that vendor's dominant customer and, thus, deserving of the best price offered by the seller? A further enhancement to the

robustness of this dissertation's findings would be the systematic inclusion of this information in future studies.

8.5 Realistically Assessing Commercial Purchasing Costs

A guiding principal followed throughout this research was that commercial purchasing costs are essentially zero. Obviously, this is not true; however, this assumption was made because of the cost and difficulty of collecting such data. Several carefully crafted case studies documenting the cost of a commercial purchasing operation would enable public policy researchers to more precisely assess the relative efficiency of the DoD's purchasing. This recommendation also dovetails with this research's assessment of the Coopers and Lybrand/TASC study, where researchers ignored the counterfactual commercial operations developing and selling commercial variants of the products the DoD was purchasing.

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